MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LV. FEBRUARY 8, 1895. No. 4

CAPTAIN W. DE W. ABNEY, C.B., R.E., D.C.L., F.R.S., President, in the Chair.

Edwin Bare, Ruthven Villa, Hainault Road, Leytonstone ;
Vincent Joseph Bouton, B.Sc., 9 Lansdowne Terrace, Hampton Wick ;
Comte A. de la Baume Pluvinel, 7 rue de la Baume, Paris ;
Henri Deslandres, D. ès Sc., Astronome-Adjoint à l'Observatoire de Paris ;
George Darley Lardner, 6 Princes Road, South Wimbledon ;
Charles William Dyson Perrins, Davenham Bank, Malvern ;
Charles A. Post, 21 Washington Square, N., New York City, U.S.A. ;
Charles Roberts, Westerham Woods, Mumhurst Road, Bournemouth ;

were balloted for and duly elected Fellows of the Society.

Report of the Council to the Seventy-fifth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1893	249	386	1	636	46	1	683
Since elected	+5	+30	...	...	+2	...	...
Deceased	−9	− 8	...	...	...	...	...
Resigned	...	− 8	...	...	...	...	...
Removals	+2	− 2	...	...	...	...	...
Expelled	...	− 6	...	...	...	...	...
December 31, 1894	247	392	1	640	48	1	689

Dr. Common's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balances, 1894 January 1 :—						
At Bankers', as per Pass Book	365	15	11			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	11	2	3			
In hand of Assistant Secretary on Petty Cash Account	0	1	4			
				376	19	6
Dividends on £13,200 Consols, 2¾ per cent. ...	351	13	6			
„ on £900 New 2½-per-cent. Stock ...	20	5	8			
„ on £1,250 Metropolitan 3-per-cent. Stock	36	5	10			
				408	5	0
Received on account of Subscriptions :—						
Arrears	155	8	0			
Annual Contributions for 1894	571	4	0			
„ „ 1895	4	4	0			
Admission Fees	67	4	0			
First Contributions	46	4	0			
				844	4	0
Composition Fees				147	0	0
Sales of Publications :—						
At Williams & Norgate's, 1893	14	19	3			
At Society's Rooms, 1894	41	8	6			
				56	7	9
Income Tax refunded by Commissioners of Inland Revenue				11	14	7

Audited and found correct, 1895 January 7.

W. B. Gibbs,
H. P. Hollis,
J. E. Drower.

£1,844 10 10

Astronomical Society, from 1894 *January* 1 *to December* 31.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
„ „ for assistance in editing Society's Publications ...	50	0	0			
				300	0	0
House Duty	2	12	6			
Fire Insurance	7	16	6			
				10	9	0
Printing	393	2	0			
Plates (Woodbury type)	15	17	6			
				408	19	6
Turnor and Horrox Fund: Purchases for Library	17	13	8			
Binding Books in Library	28	3	0			
Copying Photographs	5	18	0			
				51	14	8
Eclipse Expedition: Balance of Expenses... ...				12	12	4
Clerk's Wages	40	17	6			
Postage and Telegrams	67	18	3			
Carriage of Parcels	4	3	5			
Stationery and Office Expenses	11	5	8			
				124	4	10
Expenses of Meetings	20	0	0			
Lantern Expenses	22	5	3			
				42	5	3
House Expenses	61	7	4			
Coals and Gas	52	18	6			
Electric Light Expenses	13	6	2			
Rental of Wire for Time Signal	5	0	0			
Furniture, Fittings and Repairs	40	10	1			
Sundries	7	7	3			
				180	9	4
Lee and Janson Fund Grants	24	0	0			
Balance of Mrs. Jackson Gwilt's Annuity	1	7	0			
				25	7	0
Purchase of £250 New $2\frac{1}{2}$-per-cent. Stock, at $97\frac{7}{8}$, including Commission				245	1	3
Bankers' deductions on cheques				0	1	10
Balances, 1894 December 31:—						
At Bankers', as per Pass Book	391	15	1			
Country Cheque not credited till 1895 ...	23	2	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	13	8	7			
In hand of Assistant Secretary on Petty Cash Account	15	0	2			
				443	5	10
				£1,844	10	10

Report of the Auditors.

We have examined the Treasurer's accounts for the year 1894, and have found and certified the same to be correct. The cash in hand on 1894 December 31, including the balance at the bankers', &c., amounted to £443 5*s.* 10*d.*

The funded property of the Society has been increased during the last year by the purchase of £250 new 2½ per cent. stock.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrears for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

(Signed) W. B. Gibbs,
J. E. Drower,
H. P. Hollis.

January 7, 1895.

Trust Funds.

The Turnor Fund: A sum of £450 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £100 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £323 16*s.* 6*d.* 2¾-per-cent. Consols, the interest to be given by the Council to the widow or orphan of any deceased Fellow or Associate of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund: A sum of £300 2¾-per-cent. Consols, the interest to be given in medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1895 January 1.

	£	s.	d.	£	s.	d.
Balances, 1894 December 31:—						
At Bankers', as per Pass Book	391	15	1			
Outstanding cheque	23	2	0			
In hand of Assistant Secretary on account of Turnor and Horrox Funds	13	8	7			
In hand of Assistant Secretary on Petty Cash Account	15	0	2			
				443	5	10
Due on account of Subscriptions:—						
11 Contributions of 4 years' standing	92	8	0			
9 „ 3 „	56	14	0			
28 „ 2 „	117	12	0			
63 „ 1 „	132	6	0			
2 Admission Fees, &c....	6	6	0			
	405	6	0			
Less 2 Contributions paid in advance ...	4	4	0			
				401	2	0
Due from Messrs. Williams & Norgate for sales of Publications during 1894				7	3	7

£13,200 $2\frac{3}{4}$-per-cent. Consols, including the Turnor and Horrox Memorial Fund, the Lee and Janson Fund, and the Jackson Gwilt Fund.

£900 New $2\frac{1}{2}$-per-cent. Consols.

£1,250 Metropolitan 3-per-cent. Stock.

Astronomical and other Manuscripts, Books, Prints, and Instruments; Furniture, &c.

Unsold Publications of the Society.

2 Gold Medals.

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	7	...	XXX.	155	...
I. Part 2	42	...	XXXI.	138	...
II. Part 1	51	3	XXXII.	150	...
II. Part 2	17	3	XXXIII.	158	1
III. Part 1	65	1	XXXIV.	161	3
III. Part 2	83	1	XXXV.	106	4
IV. Part 1	78	3	XXXVI.	189	8
IV. Part 2	90	3	XXXVII. Part 1	335	8
V.	102	3	XXXVII. Part 2	280	8
VI.	120	6	XXXVIII.	265	1
VII.	142	3	XXXIX. Part 1	233	3
VIII.	126	3	XXXIX. Part 2	238	3
IX.	133	3	XL.	256	1
X.	145	...	XLI.	404	1
XI.	152	...	XLII.	229	3
XII.	159	...	XLIII.	231	1
XIII.	158	...	XLIV.	210	1
XIV.	365	...	XLV.	244	...
XV.	137	...	XLVI.	224	3
XVI.	163	1	XLVII. Part 1	3	...
XVII.	146	1	XLVII. Part 2	18	...
XVIII.	138	1	XLVII. Part 3	2	...
XIX.	148	...	XLVII. Part 4	10	...
XX.	137	1	XLVII. Part 5	8	...
XXI. Part 1	310	...	XLVII. Part 6	9	...
XXI. Part 2	98	...	XLVII.	199	2
XXI. 1 & 2 (together)	59	...	XLVIII. Part 1	240	1
XXII.	161	1	XLVIII. Part 2	245	1
XXIII.	145	1	XLIX. Part 1	407	1
XXIV.	152	1	XLIX. Part 2	277	2
XXV.	162	...	L.	289	1
XXVI.	168	1	Index to *Memoirs*	630	3
XXVII.	420	1			
XXVIII.	379	...			
XXIX.	401	...			

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	57	...	XXIX.	51	...
II.	59	...	XXX.	64	2
III.	...	...	XXXI.	93	...
IV.	...	...	XXXII.	112	5
V.	...	...	XXXIII.	94	...
VI.	45	...	XXXIV.	66	1
VII.	2	...	XXXV.	55	...
VIII.	153	2	XXXVI.	28	1
IX.	24	3	XXXVII.	35	3
X.	172	1	XXXVIII.	98	2
XI.	184	...	XXXIX.	95	...
XII.	106	2	XL.	108	3
XIII.	177	2	XLI.	108	5
XIV.	176	3	XLII.	117	1
XV.	168	2	XLIII.	114	2
XVI.	154	2	XLIV.	117	2
XVII.	167	1	XLV.	119	1
XVIII.	244	...	XLVI.	114	...
XIX.	52	...	XLVII.	132	2
XX.	32	...	XLVIII.	124	1
XXI.	16	...	XLIX.	118	9
XXII.	31	...	L.	120	11
XXIII.	18	...	LI.	121	9
XXIV.	23	...	LII.	119	12
XXV.	14	...	LIII.	121	17
XXVI.	10	1	LIV.	123	25
XXVII.	3	...	Index ...	559	5
XXVIII.	70	...			
Library Catalogue				566	2

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to LIV., no complete volumes can be formed from the separate numbers in stock.

Instruments belonging to the Society.

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatorial.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatorial.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatorial, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection :—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.
„ 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.

No. 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

„ 33. (7) 2-foot navy telescope.

„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Ys for fixing to stone piers; two axis levels.

„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

No. 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.
„ 47. (21) Box sextant ; reflecting plane and level.
„ 48. (22) Prismatic compass, by Troughton and Simms.
„ 49. (23) Mountain barometer.
„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.
„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen ; a strongly fitted brass box with heavy magnet ; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton ; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices ; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon and stand.
„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough ; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches ; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square ; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms ; two Babinet's compensators ; two double-image prisms ; three Savarts ; one positive eyepiece, with Nicol's prism ; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.

No. 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.
„ 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.
„ 91. Astronomical time watch case, by Professor Chevalier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. } Two old sun-dials.
„ 118. }
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.

No. 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere, presented by Prof. Slater.
„ 130. 10-inch brass pillar sextant, by Troughton, presented by Dr. Nevins, as executor of the late Mr. A. E. Nevins.
„ 131. Double box sextant, by Cary, presented by Dr. Nevins, as executor of the late Mr. A. E. Nevins.

Besides the above, there is the following apparatus available for eclipse work :—

4 Slits for spectroscope.
2 Abney lenses used in photographing the corona.
2 Dallmeyer negative enlarging lenses.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„ 10. Variation transit, to Mr. Maxwell Hall.
„ 16. The *Wollaston* telescope, to Mr. R. Inwards.
„ 22. The *Matthew* equatorial, to Mr. J. Brett.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 27. (1) 30-inch transit and stand, to Mr. B. T. Moore.
„ 29. (3) Wire micrometer (No. 1), to Mr. C. Thwaites.
„ „ „ Wire micrometer (No. 2), to Mr. Maxwell Hall.
„ 30. (4) $3\frac{1}{4}$-inch equatorial and stand, to Mr. E. B. Powell.
„ „ „ Double-image micrometer, to Mr. Maxwell Hall.
„ 31. (5) $2\frac{3}{4}$-inch telescope and stand, to Mr. F. J. Wardale.
„ 38. (12) 18-inch *Borda* repeating circle, to Mr. Maxwell Hall
„ 42. (16) Artificial horizon, roof, and mercury bottle, to Mr. C. Thwaites.
„ 43. (17) Hassler's reflecting circle, to Mr. B. T. Moore.
„ 50. (24) Prismatic compass, to Mr. Maxwell Hall.
„ 52. (26) Dipping needle, to Mr. Maxwell Hall.
„ 54. (28) Magnetic intensity needle, to Mr. Maxwell Hall.

No. 57. (31) Box sextant and artificial horizon, to Mr. R. J. Lecky.
„ 69. (43) Telescope with rock-crystal object-glass, to Dr. W. Huggins.
„ 76. 5-prism direct vision hand spectroscope, to Mr. E. B. Knobel.
„ 78. $9\frac{1}{4}$-inch reflector and stand, to Mr. Maxwell Hall.
„ 79. Spectroscope to Mr. Maxwell Hall.
„ 85. Double-image micrometer, to Mr. B. T. Moore.
„ 99. 12-inch portable transit instrument, to Mr. H. T. Vivian.
„ 119. Specimens of diffraction gratings, to Mr. B. T. Moore.
„ 120. 6-prism spectroscope, by Browning, to Mr. C. Thwaites.
„ 123. 6-inch refractor, by Grubb (object-glass only) to Mr. W. E. Wilson.
„ 125. 6-inch refractor by Simms, to Dr. A. A. Common.
„ 126. $3\frac{1}{2}$-inch portable refractor, by Tulley, to Mr. H. Sadler.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Dr. Isaac Roberts, for his photographs of Star Clusters and Nebulæ.

Publications of the Society.

Volume LI., Part III. of the *Memoirs* has been published during the past year, containing the following paper :—

"Comparison of the Greenwich Ten-Year Catalogue (1880) with the Cape Catalogue (1880)." By H. H. Turner and H. P. Hollis.

The attention of foreign and American astronomers is requested to the following paragraph in the Report of the Council for 1879. It is against the rules of the Society to print any paper previously published : "The Council hope that the communication between English and foreign astronomers will continue to increase, but they take this opportunity of mentioning that some of the papers which have been received by the Society have not been printed, on account of their having been previously published abroad."

Obituary.

The Council regret that they have to record the loss by death of the following Fellows during the past year :—

John Whitehouse Frederick Allnutt.
Charles Carpmael.
Arthur Cayley.
Samuel Palmer Chapman.
Edwin Clark.
Sir James Cockle.
P. Edward Dove.
Augustus S. Harrison.
Benjamin John Hopkins.
Richard Johnson.
George Knott.
James Leigh.
John Morgan.
William Peters.
Arthur Cowper Ranyard.
Rev. Henry Roe.
John Spencer.
William Tomlinson.
George Wall.

The Obituary Notice of Professor Cayley is unavoidably deferred. It is hoped that it may be printed in the next number of the *Monthly Notices*.

John Whitehouse Frederick Allnutt was born 1858 May 31. He showed ability very early, and could read fluently at four years old. He was educated at Mr. Thomas Smith's school, Southsea (1871–75); King's College, London (1875–79); University College, London (1881-82); and at the University of Cambridge as a non-collegiate student (1882–85). In 1883 he was awarded the Clothworkers' Exhibition as the most promising non-collegiate student of his year. He overtaxed his strength in reading for his degree, and in the Mathematical Tripos, 1885, his name appeared among the Senior Optimes. In 1883 he worked at practical astronomy under Mr. Turner, who was then demonstrator to the Plumian Professor of Astronomy at Cambridge, and he afterwards succeeded Mr. Turner in this capacity. He entered into the research work of the Plumian Professor with

the greatest devotion and zeal, carrying out long and laborious computations under his direction. Professor Darwin has more than once testified to the great accuracy of his work, which, although to a large extent numerical, was far from being such as could have been undertaken by a mere computer. It is doubtless due to the absorbing nature of this work that Mr. Allnutt communicated no papers of his own to the Society; he took, however, a considerable interest in our proceedings, and attended our meetings with a regularity which is the more noteworthy when it is remembered that this attendance involved a long railway journey, and that his income was not a large one. His somewhat sudden death on 1894 January 27 was due to the after-effects of influenza. He had never been very strong, and for some few years his health had been far from good. A few days before his death, however, he had appeared to recover his strength, and was preparing for work again.

He was elected a Fellow on 1887 December 9.

Charles Carpmael was born at Streatham Hill, Surrey, on 1846 September 19. He was educated at the Clapham Grammar School, under the Rev. Charles Pritchard, and gained a Minor Scholarship at St. John's College, Cambridge, in 1865. He was elected a Foundation Scholar in 1868, and graduated as Sixth Wrangler in 1869. He was elected a fellow of St. John's College in 1870; in that year he was a member of the British Eclipse Expedition, observing the eclipse with the spectroscope at Estepona, near Gibraltar; in 1871 he visited the United States and Canada, and settled at Toronto in 1872. In 1876 he was made Director of the Magnetic and Meteorological Observatory in Toronto, and in 1880 Director of the Meteorological Service of Canada. He was specially interested in magnetic observations, and devised an ingenious automatic temperature correction for the bifilar suspension of a magnet. He developed the Canadian Weather Bureau, and made many attempts to establish tide-gauges at various points on the coast, though the instruments were several times swept away by severe storms. On the formation of the Royal Society of Canada in 1882 he was appointed Vice-President of the Mathematical, Chemical, and Physical Section, and in 1885 was elected President. He served on three committees of the British Association.

He married in 1876 a daughter of the late Walter Mackenzie, Chief Clerk of the County Court, Toronto. For some time past he had been staying in the south of England for his health, and he died at Hastings on 1894 October 20. He was elected a Fellow in 1873; his papers contributed to this Society, to the Royal Society of Canada, and to the British Association, were chiefly mathematical, two of them dealing with the theory of errors. He drew up the report on the observations made in Canada of the Transit of *Venus* in 1882, and in conjunction with Professor McLeod determined the longitude of Toronto.

Edwin Clark was born at Marlow on 1814 January 7. His father was a small tradesman, and manufacturer of the pillow-lace for which the neighbourhood was renowned—an industry which came to an end on the introduction of machinery. Edwin was the eldest of three boys. (His brother, Latimer Clark, F.R.S., is well known in the scientific world, and is also a Fellow of this Society.) After boarding at an old school in the town he was at the age of eleven sent to a French school in Normandy, where in three years he acquired such a thorough knowledge of French that his translation of the *Chronicles of the Canongate* into French was published in France. He returned home in 1828, and was placed in a solicitor's office ; but scientific tastes seriously interfered with his application to this work. Such tastes were but little understood at the time, and the boy was regarded by all his friends as a ne'er-do-well. But his diligence and attention to science, especially in its practical aspects, ultimately bore fruit. He obtained a position as teacher in his old school, and one of his colleagues, who was reading for the University, strongly urged the advantage he would derive could he go up for honours at Cambridge. A small legacy of 130*l.* which his mother received at this time was devoted to this purpose. But at the end of two and a half years the legacy and the trade of lace-making had both come to an end, and his impoverished parents found it impossible to continue his maintenance at the University. After some engagements as schoolmaster, Mr. Clark resolved on an apparently reckless project. He had long wished to see something of the world, and with ten pounds in his pocket and a knapsack on his back he started on a wild and indefinite tour on the Continent. He visited the Rhine, Switzerland, and crossed the Alps into Italy, making observations on glaciers and meteorology, and various scientific collections. He became an artist, and continued his tour through Rome to Naples, Pompeii, Salerno Pæstum, and at length returned to his home at Marlow in 1839, to the great delight of his father and mother. He at once accepted a mathematical mastership at Coombe Wood, and then at Brook Green, Hammersmith, and collected a small library and a stock of scientific apparatus.

But this profession did not hold him long. In 1845 the railway mania had resulted in the great financial crisis which threw so many surveyors and engineers out of employment ; and at this inopportune juncture he suddenly abandoned the school to assist in the survey of the proposed line between Brighton and Oxford. This project speedily collapsed, but Clark's determination to be an engineer was taken. With an introduction of the most slender character, he repaired to Mr. R. Stephenson's chambers in Great George Street, an office that was destined afterwards to become his own for so many years. Mr. Stephenson was at that time overwhelmed with work, especially in the great contest between the broad and narrow gauge, and Mr. Clark was at once informed of the hopeless improbability of a personal inter-

view. But, nothing daunted, he waited patiently for hours every day in the ante-room during a period of three weeks, and at last was rewarded by a chance interview. He was fortunate enough to be able to prove his abilities almost immediately, and the foundation of his career as an engineer was laid.

The problem on which he won his spurs was that of the Britannia and Conway Tubular Bridges, for the construction of which he was ultimately placed in absolute control as resident engineer. He was for many years chief engineer to the Electric Telegraph Company, and invented and patented the hydraulic graving dock and canal lift. He constructed the great dock at Bombay, and others at Malta and London. He was the designer of a host of bridges, including the great swing bridges at Arnheim, Lyons, and Rochester, the Aire Tubular Bridge, and the Scarborough Viaduct. He was the original inventor of the block system of signalling. Mr. Clark also laid the cable from Dungeness to Holland, and negotiated the agreements and erected the telegraph for the chief English railways. He was engineer to the Crystal Palace Company, and completed the building of the Palace after the fire.

Mr. Clark was singularly careless about money ; in early life he had known poverty, and in 1873 his contracts amounted in the aggregate to five millions and a half. The change of fortune affected him but little. He retired entirely from all business in 1876, travelled for two years in South America, and finally settled down in Cromwell House in his native town. His habits were of the most simple description, but he always enjoined the maxim "that a day had been entirely lost if at its close the practical power had not been acquired of doing something that could not be done before," and his genial, happy disposition was fitly represented by his favourite motto, engraven on his sun-dial, *Horas non numero nisi serenas.*

Mr. Clark was elected a Fellow on 1858 July 9, but contributed no papers to the Society. He had, however, a keen interest in astronomy, as in all other branches of science. He was the owner of a fine 8-inch refractor by Ross, and continually used it until within a year or two of his death. He had a good astronomical library, and kept a very careful meteorological record at Marlow.

In a public lecture at Great Marlow, such as he delighted to give, he has described his early astronomical education, which began with naked-eye observations of the Moon and stars as they appeared and disappeared among the tall chimneys from a window in the East End of London. These chimneys were his transit-wires. An old German in the neighbourhood lent a copy of "Ferguson's Astronomy," and "I soon calculated eclipses, and mounted a cardboard transit instrument and equatorial on a water-butt at the back of the house."

Mr. Clark died from internal cancer on 1894 October 22. He

had suffered for some three years, and bore his long and painful illness with exemplary fortitude and patience until the last.

JAMES COCKLE was born on 1819 January 14, being the second son of the late James Cockle, formerly of Great Oakley, Essex. He was educated at Charterhouse (1829–31), and afterwards by private tuition. He left England in 1835 November, for a year's sojourn in the West Indies and the United States. On 1837 October 18, he entered Trinity College, Cambridge, graduating in 1841 (Stokes' year) as 33rd Wrangler. His subsequent eminence as a mathematician is thus a considerable encouragement to those whose position in the Tripos falls short of their expectations. Mr. Cockle was entered as a student at the Middle Temple in 1838, and practised as a special pleader, 1845–49 ; he was called to the bar at the Middle Temple on 1846 November 6, and joined the Midland Circuit at the Nottingham Spring Assizes in 1848. In 1862 April he draughted the "Jurisdiction in Homicides Act" (Imperial). From 1863 to 1879 he was Chief Justice of Queensland, and was knighted in 1869. He was Senior Commissioner for the consolidation of the Statute law of Queensland. He returned to England in 1879, and from that time till his death his leisure was devoted to the writing of mathematical papers and the affairs of several learned societies. He was elected a Fellow of this Society on 1854 March 10, and served on the Council from 1888 to 1892. He was elected a Fellow of the Royal Society on 1865 June 1, and of the London Mathematical Society on 1870 June 9, filling the Presidential Chair from 1886–88. He was President of the Queensland Philosophical Society 1863–79, and was an honorary member of the Royal Society of New South Wales.

His mathematical papers number more than eighty, and, with the exception of four on the motion of fluids, deal entirely with pure mathematics.

In the Savage Club (London), of which he was treasurer 1884–89, it was a familiar sight to see him quietly working at some algebraical research on the back of an envelope or some odd scrap of paper, though always ready to break off and offer a genial welcome to one of his friends. On committees or councils he was singularly reticent, rarely venturing a suggestion unless appealed to, but the regularity of his attendance testified to the keen interest he took in the management of business. He was a Commissioner for the Queensland Section of the Colonial and Indian Exhibition held in London in 1886 ; and was nominated to represent the Australian Colonies at the Washington Prime Meridian Conference in 1884, but was unable to accept the position.

Sir James Cockle died at his London residence on Sunday, 1895 January 27. He leaves a widow and eight children.

Augustus S. Harrison, son of Lieut. John Harrison, R.N., was born at Compton, Sussex, in 1824 August. He was educated at Christ's Hospital, London, for eleven years, where he was Senior Grecian and Mathematical Medallist. He entered Caius College, Cambridge, in 1843, and was elected a Scholar in 1844. He took the college Mathematical Prize in 1844 and 1845, and graduated as twenty-seventh Wrangler, with a third-class honours in Classics.

In 1848 he joined the Bengal Educational Department, but after serving in various positions in the Lower Provinces he resigned the service in 1862, and travelled in the hills. Five years later he rejoined the service in the North-West Provinces, and was appointed Professor of English Literature in the Bareilly College. On the institution of the Muir College in 1872, he was appointed its Principal. In 1879 he came under the age rules, but was granted an extension of service, which was renewed in 1884. Mr. Harrison was not only a mathematician and a man of science, but a Sanskrit scholar and widely read in literature. Though absent from Europe continuously for forty years, he kept well abreast of the progress of mathematical and physical science. He died very suddenly of fever on 1885 June 22, at Allahabad, though his death has only recently become known to the Society.

He was elected a Fellow on 1876 January 14, but contributed no papers to the Society.

Benjamin John Hopkins was born at Haggerston in 1862 October. His father was a journeyman carpenter and joiner, but gave up this trade some years later to take a small beer-house, in the neighbourhood of Hornsey. The son received an indifferent education at various local schools, and at the early age of ten years was kept at home to act as potboy. With the exception of another year's schooling in 1874-5, when his father had disposed of the beerhouse at Hornsey and not yet taken another, and of a few weeks' instruction at odd times, Mr. Hopkins was self-taught. His enthusiasm for science was, however, conspicuous even at this early age, and during this last year he applied himself with such diligence to the study of sound, light, and heat as to gain the certificate of the Science and Art Department in these subjects as well as for drawing and geometry. In 1875 his father took another beerhouse, "The Dog and Gun," at Canning Town, and having an invalid wife and no other children, kept his son at home to serve behind the bar. The boy now began to take an interest in astronomy, purchasing books at secondhand bookstalls with such pence as he could save from his dinner-money. His parents gave him a pocket telescope, and he managed later to purchase an old quadrant for 3*s.* 2*d.* after hard bargaining with a Jew dealer. He read his books behind the bar when business was quiet in the afternoons, and made observations in the backyard at all hours of the night. In 1876 (when only fourteen) he conceived the idea that the

rotation of comets' tails at perihelion was a phenomenon of the same nature as the rotation of the radiometer (then believed to depend on the action of light): he wondered whether the light of the Sun might not act as a repelling force on the matter composing the tail, and wrote to the President of the Royal Society (Sir Joseph Hooker), making the suggestion. Professor Stokes, to whom the letter was referred, replied at some length not only to this but to several other queries of the young enthusiast, and ultimately went to see him in 1876 December, and further recommended him to Lord Lindsay, who also visited the "Dog and Gun" to see the astronomer behind the bar. This latter visit resulted in an invitation to Dunecht, where young Hopkins spent a delightful month among instruments such as he had dreamed of, returning home with a $1\frac{1}{2}$-inch telescope, with which all his subsequent observations were made up to 1882, including that of the transit of *Mercury* in 1878. He communicated these observations to the *English Mechanic*, and afterwards wrote various letters to that journal, the most important being one describing a proposed instrument for determining the colours of stars.

He was now apprenticed to a brass engraver, and his hours of work were very long. In 1883 his mother died. In 1884 he married; in 1886 he tried, without success, to establish himself in business in the City, and passed through a time of trying poverty and reverses, happily, however, not of long duration. His interest in astronomy never flagged. He had already commenced a book on "Astronomy for Every Day Readers; suitable to be taken up by the mechanic at the close of a laborious day's work, or by the tradesman after a harassing day spent in competing with his rivals," and continued his writing throughout this period of poverty. From difficulties in finding a publisher this book did not appear till 1893; from it most particulars in this notice have been taken.

Mr. Hopkins was elected a Fellow in 1883 April. He communicated three papers to the Society, one on the Great Comet of 1882, and two on "Erratic Meteors," meteors, that is, with apparently broken paths; all three were accompanied by drawings. He wrote several papers in the *Astronomical Register*, the *Observatory*, *Nature*, *Knowledge*, and the *English Mechanic*, and as a member of the British Astronomical Association contributed frequently to its journal.

His health was never good, and he died on 1894 January 16, at the early age of 32. He leaves an invalid widow and two little girls in very poor circumstances.

Richard Johnson was born at Dublin on 1840 March 22. He obtained a classical scholarship at Trinity College, Dublin, in 1867, but afterwards devoted himself to the teaching of experimental science with considerable success. He remained at this college, unmarried, till his death on 1894 February 6,

and his rooms in college were a regular centre of attraction to his friends and former pupils. He was devoted to athletic exercises, and especially to cycling.

He was one of the observers in the Transit of *Venus* Expedition, 1874, occupying the station of Waimea, in the Sandwich Islands, and his successful observations show him to have possessed considerable astronomical knowledge.

He was elected a Fellow on 1874 May 8, but contributed no papers to the Society.

George Knott was born on 1835 October 30, and was the only son of George Knott, Esq., of Bohun Lodge, East Barnet, a well-known connoisseur of pictures, who died in 1844. At nearly the same time our late Fellow lost his mother. His early education was conducted by private tuition, but he spent two years at University College, London, and graduated at London University (B.A. in 1856, LL.B. in 1857), in the affairs of which he always took a lively interest. On attaining his majority, and coming into a sufficient fortune, he settled at Cuckfield in Sussex, and married in 1859. Here he spent a life chiefly devoted to astronomy, until the time of his death, which occurred very suddenly in October last. An accidental chill developed into pleurisy on Monday, October 1, into inflammation of the lungs on the following Friday, and on Monday, October 8, he died. He leaves a widow, but no family.

Mr. Knott's life was devoted mainly to astronomy, though he kept himself acquainted with cognate sciences and rendered unobtrusive aid to benevolent and religious institutions. His interest in his favourite science was early awakened by the late Dr. Drew, F.R.A.S., of Southampton, and his first telescope was an excellent 4-inch Gregorian reflector which had belonged to his father. In 1859 he purchased a $7\frac{1}{3}$-inch equatorial and a transit circle, and commenced systematic observations of double and variable stars and planets with the former, and of various objects with the latter ; but after a short time observations with the meridian instrument were restricted almost entirely to transits of the Sun for clock error. The observations of variables were maintained with marvellous regularity and continuity through most of the thirty-four years of Mr. Knott's working life, and his double-star observations until 1873, when he removed from his residence, Woodcroft, and built himself a new house with observatory attached, as near as possible to his old home. The building occupied a year or two, during which he lived in a smaller dwelling, and was practically cut off from observing ; and this interval he employed in arranging for press his double-star observations, which were accordingly printed in vol. xliii. of our *Memoirs*. The year 1875 saw the telescope and transit re-erected at the new house, Knowles Lodge, and the interrupted watch on variable stars was resumed ; but no serious work on double stars was again under-

taken, though a few experimental measures (chiefly for personality) are recorded. All the observations are entered with the most scrupulous neatness in a journal, and transferred to ledgers. For the variable stars there are twenty-three such ledgers, each devoted to an individual star, all of which could be put directly into the printer's hands.

A continuous series of observations of this kind, by the same observer, and with the same instrument on the same plan, is probably unique. This unswerving devotion to a particular line of research, which is at least exceptional in the case of those who work at astronomy for amusement, is the more remarkable when we remember that Mr. Knott saw the introduction of the spectroscope and of the photographic plate without being tempted away from his chosen work. And yet this persistence was far from being intolerant. So far as the spectroscope would help the particular work he was engaged on, Mr. Knott welcomed it; and notes on the spectra of the variables occur in many places in the "Remarks" to his observations. Had his time not been fully employed with the eye-observations, he would doubtless also have supplemented them by photographic observations; but as it was, the undoubted fascinations of new methods were resolutely neglected in the interests of continuity.

This note would be incomplete without a reference to the excellent astronomical library collected by Mr. Knott.

From a series of letters from the Rev. W. R. Dawes to Mr. Knott during the years 1857–1866, which have been carefully preserved, several interesting facts are made apparent. It was through Mr. Dawes that Mr. Knott obtained his telescope, and the first letter (dated 1857 September 17), obviously in reply to the first inquiries on this subject, reminds us in a striking manner of the instrumental progress made since that time. "I do not know," says Mr. Dawes, "of any large object-glass fit for your purpose to be had at present. The 8-inch I have now in use would no doubt suit you exactly, but it is already disposed of. . . . Mr. Alvan Clark, of Boston, who made it, is now constructing for me a telescope of shorter focus and a complete equatorial mounting. In the meanwhile, as my Munich equatorial mounting will be deprived of the telescope it at present carries, I have requested Clark to send me a 7-inch glass in tube &c. to fit the mounting, and if a friend of Admiral Smyth's, to whom I have promised the first offer of it, should decline it, the whole may be at your service if it would suit you."

This was the telescope which Mr. Knott ultimately obtained, and the correspondence thus opened continued with great regularity to the time of Mr. Dawes' death in 1866. The two enthusiastic observers constantly interchanged notes on their observations—chiefly about double stars. Though he had done excellent work in stellar photometry, Mr. Dawes apparently did not share Mr. Knott's affection for the variables. In 1863 October he writes: "I am heartily glad that you have not relin-

quished double-star measuring, for which, as you justly say, your O.G. is so admirably suited. Indeed, you will not wonder that, as I consider you to possess in a very high degree the essential qualities of an accurate observer of these objects, I have felt not a little jealous of such a telescope and such an observer being mainly employed on variable stars, on which, to say nothing of the observer, a vastly inferior telescope would do as well." Thus the choice of his particular line of work was entirely Mr. Knott's own, for certainly no other astronomer exercised the same influence on his work as did Mr. Dawes. In later years he corresponded chiefly with other variable-star observers (Baxendell, Birmingham, Espin, Gore, E. C. Pickering, Webb, Yendell and others) about their common difficulties. Many of these letters, too, are of interest.

It only remains to add that Mrs. Knott has not only placed these observations and letters at the disposal of the Society, but has signified her desire to contribute in a most generous manner towards the expenses of publication of the observations. Mr. Knott wrote during his lifetime more than 30 short papers, besides the double-star memoir above mentioned, but the greater part of the variable-star observations will be published for the first time.

Mr. Knott was proposed by Mr. Dawes and elected a Fellow of this Society on 1860 November 9. It is noteworthy that at this time the two friends who had corresponded so intimately had never met. It is plain from the letters that several urgent invitations were exchanged, but to no purpose until some years later. This devotion did not, however, prevent Mr. Knott from attending the meetings of this Society with the greatest regularity, although each visit entailed a midnight drive of two miles on his return to Cuckfield. He was elected on the Council first in 1868, and was a member of it with few interruptions from that time onwards.

James Leigh was born at Liverpool on 1838 June 1. His professional career as a banker commenced at Liverpool, and after being for some years at Warrington he removed in 1873 to Birmingham, and from 1876 to the time of his death was manager of the Metropolitan Bank of England and Wales. He married in 1863, and leaves two daughters and a son.

He was thoroughly engrossed in his work, and was rewarded by considerable success; his unsparing devotion unfortunately hastened his death. He rarely took part in public affairs, though he occasionally wrote to the Press on financial matters. His spare time was chiefly given to the study of natural science, especially astronomy, entomology, and ornithology. His most active period of astronomical work was in the years 1863–73, when he resided first at Rockferry, Cheshire, and afterwards at Penketh, Lancashire; and he regularly and systematically observed the Moon, noting occultations and taking micrometrical measurements of lunar craters and of double stars with an

8-inch reflector and a 4-inch refractor by Cooke, of York. His intention to resume astronomical work in 1882 was frustrated by an attack of rheumatic fever, and he was compelled to limit himself to indoor work with the microscope.

He was elected a Fellow on 1882 March 10, but contributed no papers to the Society.

John Morgan was born at Gretna on 1809 December 7. He was the younger son of the Rev. John Morgan, minister of the parish of Gretna, Dumfriesshire. In early life he went to Cartagena, in South America, and afterwards spent some years in business in Trinidad, returning with a modest fortune in 1842. Very shortly after, he came to reside at Springfield House, Bishopbriggs, with his brother William Morgan, an East India merchant, who died in 1856. Unmarried and of a retiring disposition, Mr. John Morgan lived in quiet seclusion at Springfield till his death, which took place on 1894 May 4.

Arthur Cowper Ranyard was born at Swanscombe, in the county of Kent, on 1845 June 21, and, after his father's removal to 13 Hunter Street, Brunswick Square, he was educated at University College School, Gower Street. On leaving the school he entered the adjoining college, where, from the influence of the late Professor De Morgan, whose classes he attended, he acquired a strong love for mathematics and astronomy. Whilst at University College he collaborated with Mr. George De Morgan in founding a "Students' Mathematical Society," which had a most successful career, developing eventually into the present "London Mathematical Society." Mr. Ranyard read the first paper before the new society, one "On Determinants."

From University College, London, Mr. Ranyard went to Cambridge, entering on residence at Pembroke College in the October term of 1865, and taking his degree in 1868. Three years later he was called to the Bar at Lincoln's Inn, but, whilst adopting the law as his profession, his leisure hours were mostly devoted to science. Thus he joined the Physical Society in its first session, and in 1872 worked with Lord Lindsay (the present Earl of Crawford) in the study of photographic irradiation. Again in 1885 and 1886 the same subject of photography occupied his attention, and he conducted a number of experiments in order to determine the relations between the length of exposure and the intensity of photographic action.

His connection with Lincoln's Inn gave scope for the exercise of another side of his character, his interest in relics of the past. The preservation of ancient monuments appealed strongly to him, and he took a great part in saving the old gateway of Lincoln's Inn from destruction, and also the houses in "Old Buildings," including Lord Thurlow's chambers. In the latter he was especially interested, as the character of Cromwell himself, and

the incidents of the Cromwellian *régime* had been a favourite subject of study with him.

His chief work as an astronomical observer consisted in his observations of the three total solar eclipses of 1872, 1878, and 1882. On the first occasion he was one of the observers sent out by the Joint Committee of the Royal and Royal Astronomical Societies, and was stationed at Villasmunda, near Augusta, Sicily. He was here favoured with much better fortune than awaited most of his colleagues, and was afforded a fine view of the phenomena of totality. The observations assigned to him were polariscopic, and he carried them out with entire success, repeating, with a few additional details, those made by Prazmowski in 1860. His expeditions to America to view the total solar eclipse of 1878, and to Egypt to view that of 1882, were made at his own expense, and he went on his own responsibility. He was contemplating an important work in the department of solar physics on the lines opened up by M. Deslandres and Professor Hale, when the disease which afterwards proved fatal laid its hand upon him. He had had a spectroheliograph constructed for him, and this he lent to Professor Hale for the latter's expedition to Etna to attempt the photographing of the corona in full sunshine. Mr. Ranyard never had the opportunity of using the instrument himself, and it lay in its cases, not yet unpacked, at the time of his death. He willed it, together with the Calver reflecting telescope, for which it was designed, to Mr. J. Evershed, a Fellow of this Society.

Mr. R. A. Proctor's sudden death in 1887 left the publication of his great work, *Old and New Astronomy*, in a most unfinished state, and his magazine, *Knowledge*, without an editor. It was exceedingly typical of Mr. Ranyard's generous spirit that he cheerfully undertook the immense amount of hard work, extending over many months, which the completion of the *Old and New Astronomy* involved, in order to sustain the reputation of his deceased friend and to assist his family. And difficult as it was to follow a man of Proctor's ability, and to sustain his work upon an equal level, Mr. Ranyard fully succeeded in the task.

The subjects which he chiefly discussed in these two publications were: the conditions of the various envelopes of the Sun, the structure of the solar corona, the structure and dimensions of the stellar universe, the distance of the Milky Way, and the density of nebulæ, of the great *Orion* nebula in particular. The especial feature which he introduced into *Knowledge* was the reproduction of a number of important astronomical photographs, a feature very gratefully welcomed by many astronomical amateurs. He devoted also considerable space to the reproduction of photographs of lightning and to the discussion of the phenomena of "ribbon flashes" and "dark flashes."

Another publication undertaken by Mr. Ranyard was that of Professor De Morgan's little brochure, *Sir Isaac Newton, his Friend, and his Niece*, to which he supplied a preface. Nor

was the reputation of Sir Isaac Newton the only one in which he was interested. He was anxious that the gifted young pioneer of English astronomy should have due honour rendered to him, and was instrumental in having a memorial tablet erected to Jeremiah Horrox in Westminster Abbey.

He took an active part in public affairs and was very earnest in promoting the establishment of the St. Giles's Public Library, of which he was one of the Commissioners. He consented to stand as one of the candidates for the Holborn Division in the County Council election of 1892. His good temper and evident straightforwardness and honesty made the most favourable impression on the electors, and he and his colleague, Mr. Remnant, were the only two candidates of their party who succeeded in winning seats from their opponents at that election. Many of his friends feared that he was thus taking a burden upon him too heavy for his strength, knowing the thorough conscientiousness with which he discharged every duty that he undertook. Thus, in the year ending March, 1893, he had attended every meeting of the County Council, and almost every meeting of the committees on which he was serving. Of these the one in which he effected the most important work was the Building Acts Committee, especially in connection with the New (London) Building Act, with reference to which he gave evidence before a Select Committee of the House of Commons.

His connection with the Royal Astronomical Society began at an unusually early age, he having been elected a Fellow when only 18. His first work in an official capacity was in the preparation and organisation of the Eclipse Expedition of 1870 ; Mr. J. Norman Lockyer being appointed Secretary of the Joint Eclipse Committee of the Royal and Royal Astronomical Societies, and Mr. Ranyard, Assistant-Secretary. He was elected to a seat on the Council in February, 1872, and to the Secretaryship in February, 1874. This office, which he retained till 1880, he filled with conspicuous industry and courtesy. During his tenure of this office he brought out vol. xli. of the *Memoirs*, the great "Eclipse" volume. In its inception it was intended to be a report of the eclipses of 1860 and 1870, and at first Mr. Ranyard worked with the assistance and under the oversight of Sir G. B. Airy, then Astronomer Royal. Soon, however, the entire work devolved upon him, and its scope was extended until it embraced the collation and arrangement of the known observations of all eclipses down to 1878. This work, most admirably designed, and most laborious in execution, was not published until 1879.

Including the years of his secretariate, he sat nineteen years upon the Council.

Early in the summer of 1894 a mysterious loss of weight and other disquieting symptoms began to make themselves apparent. These were eventually traced to the formation of an internal cancer which all but precluded the possibility of nourishment

entering the system. After a long and most trying illness, borne with great patience and hopefulness, he died on December 14, 1894, whilst the meeting of the Royal Astronomical Society, in the welfare of which he took from first to last so keen an interest, was in session. Mr. Ranyard was not married, and only one of his immediate relatives, a brother in Australia, survived him. But his purity of motive, his generous spirit, his freedom from self-seeking, and his unfailing courtesy of manner, endeared him to a large circle of friends who will keenly feel his loss. Amongst these will be numbered not a few of the most distinguished foreign astronomers, Mr. Ranyard having been an excellent linguist, and frequently visiting the Continent. He was elected a Fellow of the Society 1863 November 13.

Henry Roe was born at Corfe Castle, Dorset, on 1833 October 22. At the age of nineteen he became tutor and Government Lecturer in Mathematics at the Metropolitan Training Institute, Highbury, and held this office till 1865, when he took Orders and was appointed to the Head Mastership of Kineton Middle School, and the Curacy of Combroke. While holding these offices he became Evening Lecturer at Tysoe (1869–75), and then for a short time Chaplain of Chadshunt. In 1876 he was presented to Poyntington and made Chaplain of the Sherborne Union, and was for seven years (1877–84) also Assistant Diocesan Inspector. He remained at Poyntington for twelve years, for the last eight of which he was Curate of Sherborne. In 1883 he became Rural Dean of Merston; in 1884 Diocesan Inspector for the Archdeaconry of Taunton, and the Rural Deaneries of Merston, Ilchester, and Paulet; and in 1886 he was made Prebendary of Ilton in Wells Cathedral. He was appointed to Yeovilton in 1888 by the Bishop of the diocese.

Prebendary Roe was on the General Committee of the Exeter Congress and a member of the small but very important "Subjects Committee." He married in 1858 and leaves two sons and two daughters. He died at Yeovilton Rectory on 1894 September 16 after a four days' illness, and his widow only survived him by seventeen days.

He was elected a Fellow on 1864 February 12, but contributed no papers to the Society.

William Tomlinson was born at Ilkley, Yorkshire, on 1809 December 4. In 1846 he became a master in the Royal School of St. Peter at York, where he was subsequently placed at the head of the Civil and Military Department. This post he retained until his resignation in 1873. In 1882 he left York for the milder climate of Sandown, Isle of Wight, where he died, 1894 January 17.

Mr. Tomlinson attained a considerable reputation as a successful and enthusiastic schoolmaster throughout the country. He was an able mathematician and an ardent lover of the natural

sciences. His health was remarkably good, and to the last he retained his faculties, his powerful analytical mind losing nothing of its acuteness.

He was elected a Fellow on 1855 January 12, but contributed no papers to the Society.

GEORGE WALL was born 1820 December 20, in the neighbourhood of Manchester. He was educated at home, and on account of his weak health he went out to Ceylon in 1846, and founded, in 1854, the firm of George Wall & Co., Coffee Merchants and Estate Agents, in Colombo. In 1856–57 he filled the office of Chairman of the Planters' Association, and in 1858 was elected Planting Member of the Legislative Council. He returned to England in 1859, and till 1863 was partner in the firm of Sir Joseph Whitworth & Co., Manchester, and took a leading part in the manufacture and testing of their small arms, which created so profound a sensation in military circles at that time. Mr. Wall again went to Ceylon in 1863, and in 1866 was elected Chairman of the Chamber of Commerce; he came back to England in 1868 as delegate representing the Colony in the Parliamentary inquiry into the affairs of Ceylon, and on his return was again Chairman of the Chamber of Commerce, from 1874 to 1879.

Up to this time Mr. Wall had a good observatory at each of his two residences, and devoted much time and expense to astronomical studies. But in 1879 the firm of George Wall & Co. failed, chiefly through the devastation of the coffee crops by blight, and from this time his more reduced circumstances, as well as failing eyesight, prevented his further pursuit of astronomy.

In 1892 the Cobden Club awarded their gold medal to Mr. Wall for his services in connection with the abolition of the Ceylon Grain Tax. He was twice married, and leaves a widow and thirteen children. He died 1894 December 18.

Mr. Wall was a Fellow of the Linnean Society, and was elected a Fellow of the Royal Astronomical Society 1872 February 9. He was the author of several books, including an abstruse work entitled "The Natural History of Thought."

Proceedings of Observatories.

The following reports of the proceedings of observatories during the past year have been received from the Directors of the several observatories, who are alone responsible for the same :—

Royal Observatory, Greenwich.

Notwithstanding the cloudy weather which prevailed through a great part of the year, the large number of observations made with the transit-circle in 1893 has been equalled in 1894 ; the total number of transits observed during the year being 10884, and of meridian zenith distances 10694. The total number of stars observed with the transit-circle during the year is 3057.

The mean error in R.A. of Hansen's Lunar Tables with Newcomb's Corrections, as deduced from 101 observations with the transit-circle is $-0^{s}\cdot019$. For the years 1883 to 1893 the errors are $+0^{s}\cdot032$, $+0^{s}\cdot021$, $+0^{s}\cdot028$, $+0^{s}\cdot029$, $+0^{s}\cdot068$, $+0^{s}\cdot079$, $+0^{s}\cdot010$, $+0^{s}\cdot020$, $+0^{s}\cdot079$, $+0^{s}\cdot069$, and $+0^{s}\cdot036$.

The apparent correction to nadir observations deduced from reflexion observations of stars ranges from $0''\cdot00$ to $-0''\cdot50$ for the several months of the year. The mean correction for the year is $-0''\cdot271$, which agrees with the results for 1892 and 1893. For the years 1890 to 1894 the corrections are $+0''\cdot08$, $+0''\cdot07$, $-0''\cdot25$, $-0''\cdot34$, and $-0''\cdot27$.

The series of observations begun in 1893 in which the direct observation of zenith distance was taken before the reflexion was continued in the early part of 1894, 103 observations having been made. The bearing of these observations (130 in all) on the R − D discordance is discussed by Professor Turner and Mr. Thackeray in a paper which will be published in the *Memoirs of the R.A.S.*, vol. li.

During the year twenty-five determinations of horizontal flexure of the transit-circle were made.

A series of observations was begun in December in which pairs of stars, of nearly the same North Polar distance, and at an interval of 5 or 10 minutes in Right Ascension, were observed in zenith distance, the one directly, and the other by reflexion, alternately on alternate nights. It is hoped, by these means, to obtain further information on the nature of the R—D discordance.

The Moon was observed with the altazimuth in the first and

last quarters as in previous years. Sixty-three observations were made in the year. The building for the new altazimuth or universal transit-circle is in progress, the concrete piers for the instrument and collimators having been erected. The instrument is practically completed and will be mounted as soon as the building is ready.

Three comets were observed during the year with the Sheepshanks' equatorial, namely :

Comet (*a*) 1894 (Denning)	on	6 nights.
„ (*b*) 1894 (Gale)	„	26 „
Encke's Comet	„	3 „

Sixteen occultations of stars by the Moon and twenty-five phenomena of *Jupiter's* satellites were observed with the equatorials by one or more observers. No observations of the transit of *Mercury* were made on November 10 owing to clouds.

The observatory has received from Sir H. Thompson a valuable gift of 5000*l.* to provide a large photographic telescope of 26 inches aperture and 22 feet 6 inches focal length with accessories, which would serve as the complement of the 28-inch visual telescope. This telescope, which is being made by Sir H. Grubb, will be of exactly double the dimensions (aperture and focal length) of the astrographic equatorial, which has proved so successful, and will be mounted on a very firm stand which will allow of complete circumpolar motion, without the necessity for reversal on the meridian. It will be erected on the central tower of the new Physical Observatory, under the 30-feet dome. The south wing of the new Physical Observatory was completed on April 30, and has been occupied since the beginning of June. The building of the north wing and completion of the central octagon was begun in September, so that the building will soon be ready for the erection of the dome.

With the 28-inch refractor three different kinds of observations have been made.

(1) The telescope was adapted to photography by reversing the crown lens and separating the lenses according to the plan proposed by Sir G. G. Stokes. A large number of photographs were taken to determine the best distance between the lenses and the exact adjustment of the crown lens for tilt and centring relatively to the flint. Interesting information was obtained which will be useful in connection with the Thompson 26-inch photographic telescope.

(2) The half-prism spectroscope has been very firmly mounted on the tube of the telescope and parallel to it, two reflecting prisms being employed to bring the light from the telescope on the slit of the spectroscope. The adjustment of the spectroscope to focus and collimation, having to be made step by

step, took a considerable time, and was much hindered by the cloudy weather during the latter half of the year.

(3) The visual observations consist of measures of twenty-one double stars on thirty nights, of the satellites of *Mars* on two nights, sketches of *Mars* on two nights, and of *Jupiter* on one night, of measures of *Jupiter's* equatorial and polar diameters on three nights, and of the diameters of *Jupiter's* third satellite on one night. The measures of diameter of *Jupiter's* satellites are being continued. Attempts were made to measure *Jupiter's* fifth satellite, but the results obtained were discordant.

With the astrographic equatorial 694 plates with 1600 exposures have been taken on 151 nights, and of these 183 have been rejected—viz., 62 fogged, 35 faulty *réseau*, 38 sky cloudy, 15 wrong setting, 5 put wrongly in the carrier, 13 spoiled in development, 8 injured or broken, and 7 for miscellaneous defects. The number of rejections is unusually large.

The shutter of the dome was blown away in the gale of December 22, but fortunately the observer who was in the dome at the time escaped unhurt, and no damage was done to the instrument. The instrument has necessarily been out of use since this date.

The progress made with the photographic mapping of the heavens during the year 1894 is as follows :

	No. of Plates taken.	Successful Plates.
Astrographic Chart (Exposure 40^m)	196	155
Plates for Catalogue (Exposures 6^m, 3^m and 30^s)	401	259
Number of fields photographed for the Chart ...		140
Number of fields photographed for the Catalogue		220
Total number of fields photographed since the commencement of the work for the Chart ...		408
Total number of fields photographed since the commencement of the work for the Catalogue		618

When practicable a trail has been taken each night on a catalogue plate, and during the year 88 plates with trails have been secured.

The following miscellaneous photographs have also been taken :

	No. of Photos.
For adjustment of Equatorial	11
Pleiades	5
Typical Areas	39
Various regions	4
With the enlarger (14 times)	7

Each plate has undergone a preliminary examination to see whether it was generally satisfactory, and whether the adopted

limits of magnitude were approximately reached as inferred from the 20^s exposure, which should give 9th magnitude stars of Argelander's scale.

It was found on the commencement of the measurement of the plates that it was necessary to reject a certain number of partially fogged plates which had previously been passed.

For the measurement of the photographs a glass diaphragm, with two scales at right angles divided to $\frac{1}{20}$th of a millimetre, is placed in the focal plane of the microscope of the astrographic micrometer. The star's image is placed accurately at the intersection of the two scales, and the position of the *réseau* lines relatively to it is read off on the scales by estimation to $\frac{1}{200}$th of a millimetre, *i.e.* 0·001 of a *réseau* interval, or $0''.3$, in the heavens. In a note communicated to the Society (*M.N.* 1894 December) an account is given of the measurement and reduction of four overlapping plates. The result of these preliminary measures was considered so far satisfactory that systematic measurement of plates was begun in October and the 6^m and 3^m images of 1535 stars have been measured.

A new duplex micrometer has been arranged in which the overlapping portions of two plates can be measured at the same time. The plates are placed in a frame movable in one direction, and the carrier of one of the plates can be adjusted so that the images of the same star on the two plates are very approximately in the same horizontal line. Two microscopes carried on a horizontal slide move perpendicularly to the direction in which the frame moves, and their distance apart can be so adjusted that when the image of a star on one plate is at the centre of the field of one microscope the image of the same star on the second plate is within $\frac{1}{10}$th of a millimetre of the centre of the field of the second microscope. Much time is thus saved both in looking for stars and in their subsequent identification.

Photographs of the Sun have been taken with the Dallmeyer 4-inch photoheliograph on 177 days, and of these 323 have been selected for preservation, including fourteen photographs with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination.

The Dallmeyer photoheliograph was mounted during the first four months of the year on the new 28-inch refractor, but on April 24 it was transferred to the south wing of the new building in the south ground, upon the terrace roof of which it was mounted, together with the wooden hut which had formerly sheltered it.

Photographs of the Sun have also been taken with the Thompson photoheliograph on 143 days during the year, and of these 235 have been selected for preservation. Observation with the Thompson instrument has been discontinued since 1894 October 15, the progress of the works on the new building interfering with its use. A few photographs have also been taken with a third instrument, the Dallmeyer photoheliograph, No. 4,

which has been prepared for employment at the Madras Observatory, at the request of the Indian Government, by being fitted with a new enlarging lens by Ross and a camera for taking photographs of the Sun 8 inches in diameter. In all, photographs of the Sun have been taken at Greenwich with one or other of the photoheliographs on 219 days during the year. Photographs have also been received from India and Mauritius up to 1894 September 26, leaving only two days, 1893 December 31 and 1894 January 1, for which no photograph is yet available for measurement in the year ending with the date of the last Indian negative received.

The Greenwich photographs have been measured in duplicate up to the end of 1894, and the areas and heliographic positions of the spots and faculæ have been computed. The complete results for 1892 have been printed, and those for 1893 are nearly ready for press, and a portion has already been sent to the printer. The work is, however, exceedingly heavy, from the number, size, and complexity of the groups of spots observed in 1893.

A falling off in the solar activity, as evidenced by Sun spots, has been remarked during 1894, but though several fine disturbances have been recorded, particularly that of the latter part of 1894 February, and the Sun has never been without at least three or four distinct groups of spots, there has been nothing to fully equal the displays of 1893 August and December.

The reduction of the Greenwich—Waterville—Hazel Hill—Montreal longitude determination has been delayed owing to an apparent discordance between the first and fourth stages of the results for Waterville—Hazel Hill, which was eventually traced to a misapprehension in the numeration of the seconds at Hazel Hill. The final results will now be given shortly.

Transit observations have been made on six nights at contiguous stations in the front court to determine the difference of longitude between them with the same instruments as were used in the Paris—Greenwich longitude determinations. The results, as far as they go, confirm those obtained in 1893, and are unfavourable to the existence of any anomalous difference of longitude. More observations will, however, be made as circumstances permit.

Mr. Plummer, the Director of the Bidston Observatory, in the course of a determination of the longitude of Bidston, was at Greenwich from January 1–9 and from April 21 to May 1 for the purpose of comparing his personal equation with that of the standard observer at Greenwich.

The volume of Greenwich Observations for 1892 has been printed, and is in the binder's hands. The printing of the volume for 1893 is advancing.

An event occurred in the year which might have done serious damage, a bomb having been exploded on February 15 close to the Observatory by an Anarchist, who was killed by it.

Mr. Turner resigned his position as Chief Assistant on February 28 to take up his appointment as Savilian Professor of Astronomy at Oxford, and was succeeded by Mr. Dyson on March 1. The clerk, Mr. Le Brun, found himself compelled by ill-health to resign on March 19. From April 2 Mr. Cass from the department of the Accountant-General of the Navy, carried on temporarily the cash and clerical duties till May 21, when Mr. H. Outhwaite from the Admiralty was appointed as clerk. There are still two vacancies among the Second Class Assistants.

Royal Observatory, Edinburgh.

The close of the year 1894 saw the buildings of the new Royal Observatory quite finished as far as regards the outside. The most prominent features are decidedly the two cylindrical domes. These were erected by Sir Howard Grubb in such good time last summer, that it was possible to overlay them with copper and complete the tasteful ornamentation before the winter set in. The copper work was entrusted to Messrs. Ewart, of London. When the domes were completely finished the copper was washed down with a saline solution to hasten the uniform colouring of the metal. The green tint thus produced in a few days has added considerably to the appearance of these structures, which have excited general admiration for their elegant and imposing appearance.

Several months must elapse before all the rooms of the observatory are ready for occupation. The domes have still to be fitted with storm shutters and apparatus for opening and closing the roof. The storm-shutters, by partly closing the side opening from below, are designed to screen the observer and the instrument from the more violent winds which so often seriously interfere with the efficient use of a large telescope. The piers are ready for the stands of the two equatorials which will be erected in the early part of the summer. The library, which is shelved for about twenty thousand volumes, is ready to receive the books. These will be provisionally arranged as soon as the warming apparatus is in working order. The transit house has proved a heavy piece of work, owing to the novelty of the plans; but a few months, it is hoped, will see the transit-circle in position.

During the month of November all the instruments and books that still remained at Dunecht were removed to Edinburgh, some seventy tons in all. These are now being gradually unpacked as space becomes available for them. The Siderostat has been adapted to the latitude of the new observatory, the new angle-block having been cast, and the other necessary alterations carried out, by Messrs. Dove & Co. of this city. This and other instruments at Blackford Hill have been under the

charge of Mr. A. J. Ramsay, who has secured a series of photographs showing the progress of the buildings.

The gate-lodge has been occupied for some weeks by the caretaker, and the dwelling-houses for the director and staff will be ready for occupation by the end of April.

At the Calton Hill the arrangements for time signalling by ball and gun have been the same as in former years, and it is intended to continue the present service until everything is ready for transferring the work to Blackford Hill.

During the year the new reduction of the early Edinburgh transit observations has made steady progress in the hand of Mr. Heath, the instrumental errors in 1834–5 having been completely deduced afresh. The individual right ascensions for this period are for the greater part computed, the published mean wire results having been first compared with the original note-books.

A few additional observations for latitude have been made with the mural circle and partly reduced.

A bi-filar pendulum, designed to show tilts of the foundation on which it is placed, was temporarily erected on the rock at Calton Hill, on March 24, at the request of M. Antoine d'Abbadie, who provided the instrument. It was constructed by Mr. Horace Darwin, on the principle suggested by Lord Kelvin. Daily observations have since been made at Paris mean noon, simultaneously with the readings of M. d'Abbadie's nadirane, at Abbadia in the South of France. A copy of the observations made up to December 31 has been sent to M. d'Abbadie, but it is evident that only a continuous photographic record will bring out the full capabilities of the instrument.

Three circulars referring to comets—Denning, Gale, and E. Swift respectively—were issued in the course of the year.

Royal Observatory, Cape of Good Hope.

The reduction of the staff, created by the illness of Mr. George Maclear since 1892 April, and his subsequent retirement in 1893 June, has been the subject of official correspondence, but the post has not yet been filled; besides this, one member of the staff has been seriously ill for two months, and thus the work of the observatory has been still further crippled. Meridian observations have been resumed, but they have been restricted in number to those absolutely necessary for completing the observing list of stars to be contained in the general catalogue for 1890. Observations of the *Sun*, *Mercury*, and *Venus* have not been resumed. H.M. Astronomer regrets the necessity for adopting this policy, but there remains for him only the choice of adding to the already large stock of unreduced and undiscussed observations, or of limiting the work in some such way till an adequate staff is provided.

With the transit-circle there have been made :

Transit Observations	4818
Observations of Declination	5063
Determinations of Collimation	96
„ Level	292
„ Azimuth	293
„ Run	279
„ Nadir	265
„ Flexure	46

The following occultations of stars by the Moon were observed :

Disappearances at the dark limb	7
Reappearances „ „	10
No. of separate phenomena	17

With the zenith telescope 512 observations have been made for aberration and change of latitude.

With the 7-inch equatorial the following comets have been observed :

Gale's	Comet	on 15 nights
Tempel's	„ 1873 II.	„ 5 „

With the photographic telescope the following work has been accomplished :

	No. of plates Exposed.	Exposures. No.	Exposures. Duration.
Catalogue plates	563	1689	6^m, 3^m, 20^s
Chart „	253	253	up to 1 hour
Kapteyn-Pritchard areas	81	243	6^m, 3^m, 20^s
South Polar area	4	12	6^m, 3^m, 20^s
Comparison of areas in various galactic latitudes }	7	14	20^m
Trails for speed of plates, adjustments, &c. }	6	—	—
η Argûs	1	9	total 25 hours

For investigating form and period of light-curve of new variable star in Vela (Gould, 13052) :

Jan. 25 to April 1 (normal mag.)	37	39	6^m, 3^m, 20
Feb. 1 (varying mag.)... ...	4	21	6^m, 3^m, 20^s
7 „	9	81	6^m, 3^m, 20^s
13 „	8	63	6^m, 3^m, 20^s
Apr. 13 „	7	109	6^m, 3^m, 20^s
19 „	4	25	6^m —
25 „	5	39	6^m —
Dec. 12 „	4	16	6^m —
18 „	3	15	6^m —
30 „	1	21	6^m —
	799	2649	

At the Cape, the programme of the International Astrophotographic Congress has been realised to the following extent. After rejecting all plates of insufficient exposure, poor images or which are otherwise faulty, only 70 of the Catalogue plates, out of 1632 areas allotted to the Cape, remain to be done. Of the Chart plates, 263 have been passed as satisfactory.

Two sets of overlapping plates extending over the area covered by the *Victoria* Comparison Stars have been measured by two independent observers for the purpose of determining the optical distortion of the field, and other constants necessary for the reduction of the Catalogue Plates.

The diameters of the discs of the Variable Star in Vela, together with those of nine comparison stars, have been measured for all plates taken up to the end of April. The results show that the star is a variable of the Algol type, its period being about $5^d\ 22^h\ 24^m\ 4^s$. The star's variability was discovered by Mr. C. Ray Woods from a comparison of plates taken on 1893 March 18 and 1894 January 20. A complete discussion of the period will shortly be undertaken.

The state of the printing and reduction of Meridian Observations is as follows :

The Cape *General Catalogue* for 1885·0, with an Introduction, including a discussion of the Latitudes and Refraction Corrections at Greenwich and the Cape, and with an appendix containing a fundamental catalogue of circumpolar stars, has been passed through the press, and is now in the hands of the binders.

The *Meridian Observations* 1885–87, with Introduction, have been passed through the press, and some printed copies were received at the Cape on November 22.

The MS. of results of Meridian Observations 1888–89 was sent to the printer on October 17.

The Meridian Observations 1890–91 are ready for the printer.

The computations of	Mean R.A.	are complete to	1894	July	20.
,, ,,	,, N.P.D.	,,	,,	Sept.	21.
,, ,,	Apparent R.A.	,,	,,	Dec.	2.
,, ,,	,, N.P.D.	,,	,,	Dec.	15.

The results of Meridian Observations of 480 Southern Fundamental Stars from 1885 to 1894 June have been communicated to Professor Auwers.

The observations of comets are reduced and the results have been communicated to the *Astronomische Nachrichten.* Meridian Observations of all the comparison stars were secured towards the end of the year, but they are not yet fully reduced.

The discussion of the Heliometer Triangulation of the *Victoria* Comparison Stars, and the details of the Heliometer Observations of *Victoria* and *Sappho*, have been passed through the press.

The preliminary discussion of the observations of *Victoria*, leading to the discovery of an error in the hitherto adopted value of the lunar equation, has been passed through press. The MS. of the definitive discussion of the observations of *Victoria*, based on the new ephemeris referred to in last Report, was forwarded to the printers on December 12. A photographic copy of this manuscript has been sent to Prof. Simon Newcomb.

The MS. of the Cape *Photographic Durchmusterung*, vol. i., was forwarded to the printers on June 19; the definitive specimen page was finally settled, and the work of printing put in hand on October 10.

It has still remained impossible with the inadequate computing force of the observatory to attempt the reduction of the Heliometer observations for stellar parallax, the observations of the mutual distances and position-angles of *Jupiter's* satellites, the zenith-telescope observations, the measures of *réseaux* and photographic plates, and the reduction of the occultations observed since 1881.

The reduction of the meridian observations of the Sun, Moon, and fundamental stars made under the direction of Sir Thomas Maclear, 1861–70, has been commenced.

The printing of the results of the Geodetic Survey has been entrusted to the Cape Government printers. The work is of a character to which they are unaccustomed, and makes slow progress; 160 pages (less than half of the whole) have been passed through the press during the year.

A noble offer has been made by Mr. Frank McClean, viz. to present to the Cape Observatory a large refractor equipped for photographic and spectroscopic work. The photographic telescope to have an aperture of 24 inches and $22\frac{1}{2}$ feet focal length, and be provided with an objective prism of the same aperture, having a refracting angle of $7\frac{1}{2}$ degrees; the visual telescope, to be mounted parallel to the photographic telescope, 18 inches aperture, and the same focal length as the photographic telescope. The equatorial mounting will have complete circumpolar motion for 30° within the zenith, and be sufficiently elevated to allow use of a fair-sized spectroscope suitable for determining stellar motions in the line of sight. Such a spectroscope will be provided, as also an observatory of light construction. The instrument has been for some time under construction by Sir Howard Grubb. The Lords Commissioners of the Admiralty have accepted, with warm appreciation of Mr. McClean's generosity, the offer of this splendid instrument, and have expressed their view that the possession of this instrument will greatly increase the utility of the Cape Observatory, and may be expected to result in considerable advantage to science. Sir Howard Grubb reports that the objective prism is finished, and that a perfect crown disc has been received from M. Mantois for the 24-inch object-glass.

Professor Harold Jacoby, of Columbia College, New York, is at present on a visit to the Cape Observatory. He has devoted

some time to questions connected with the determination of errors of scales and *réseaux*, and has communicated a paper to the *Astronomische Nachrichten* on the subject. At the request of H.M. Astronomer he is undertaking a discussion of the measures of the above-mentioned series of plates of the *Victoria* Comparison Stars.

The time-signal service has been regularly continued. A new time-ball has been erected on an elevated site near the Cape Town Docks, and the fall of the ball is now automatically registered on the chronograph. No error or failure has occurred since the erection of the new ball.

The meteorological observations made at the observatory in 1894 have been communicated for publication to the Cape Meteorological Commission.

The Observatory, Armagh.

During the past year the refractor has chiefly been used for observations of double stars, an endeavour being made to select objects which have not been too frequently observed of late years.

The ingress of *Mercury* on the Sun's disc on November 10 was not seen, owing to a bank of clouds which covered the Sun until about fifteen minutes after internal contact. The planet was then well seen for about six minutes, and appeared as a uniform dark disc without any trace of a halo. The definition was good, notwithstanding the low altitude.

An index catalogue of all the nebulæ found since the publication of the N. G. C. and up to the end of 1894, has recently been sent to the Society. The paper on micrometric measures of nebulæ referred to in last year's report was published in September.

Cambridge Observatory.

The most important part of the work done in this observatory during the year has been the completion of the catalogue of Argelander's stars, which have been observed here in co-operation with the Berlin *Astronomische Gesellschaft*. To facilitate this work an extensive set of tables for calculating the secular variation of the precession in right ascension and declination, supplementary to the tables already calculated for the precessions themselves, was completed on February 10. The mean places for the epoch 1875·0, deduced from each individual observation, are entered in a comprehensive catalogue, which is now complete with the exception of dates and precessions in right ascension for the last four hours. A smaller catalogue, giving the mean places for each star deduced from all the observations of that

star, and arranged to correspond with the other volumes of the series published by the *Astronomische Gesellschaft* is being copied for the press. It is all prepared, and the first seven hours of right ascension are ready to be placed in the hands of the printer.

The transit circle was used on 147 nights, chiefly in observing clock stars, stars for instrumental correction, zone stars which it was thought desirable to re-examine, *Mars* near the opposition, observations for personal equation, and a few for the inclination of the wires, making in all 1456 meridian observations.

The nadir point was observed 121 times, in sixty of which the bisections were made on both the north and south sides of the telescope. The results prove that when the observer stands on the south side of the telescope the nadir point still comes out slightly greater than when on the north side.

The level and collimation were each observed 138 times, and 36 observations were made to obtain coefficient of flexure.

On March 20 the gas was introduced into the transit room, and two incandescent burners were fitted on for illuminating the microscopes, the wires in the transit telescope, and the collimating eye-piece. These burners give a pure white light very comfortable for the observer.

Ninety-five comparisons of Gale's Comet with neighbouring stars were obtained on ten separate nights in May and June with the Northumberland equatorial and square bar micrometer. From those of May 4, May 23, and June 11, a very satisfactory orbit was obtained, which has been published in the *Notices*.

Repeated applications for accurate places of stars have been made during the year. Those included within the limits of our zone were found in the catalogue and forwarded at once; the others have been observed or are in process of observation just now.

The Newall Telescope, Cambridge Observatory.

The Newall telescope has been used for observation on 121 nights in the course of the year 1894, the later part of the year being very unfavourable for observations.

The experimental trials of different prism arrangements for a slit spectroscope for photographic purposes were completed in the spring. On the results of the trials was based a design of a spectroscope, and the instrument itself is now very nearly completed.

The study of the spectrum of α Orionis by photographs was continued in the spring, partly with one objective prism and partly with a direct vision slit spectroscope.

A number of photographs of stars have been taken under different conditions with a view of testing the performance of the

visual object-glass in photographic work, and some of the results are recorded in a paper in the *Monthly Notices*, vol. liv. p. 373. Some peculiar features presented themselves in some of the star images, and further study of them brought to light some interesting results, many of which are embodied in a paper in the *Monthly Notices*, vol. liv. p. 515.

Photographic enlargements of some of the planets have been taken with some promise of greater success. The coarser detail of the Moon is well shown in some enlargements taken with the same enlarging apparatus attached to the telescope.

It seemed best whilst the spectroscope was being made, to desist from further attempts to work with makeshift spectroscopes, and to undertake some micrometrical work. The inner satellite of *Mars* was accordingly observed on all possible occasions in the autumn, and a considerable number of measurements were obtained in spite of very unpropitious weather. The fifth satellite of *Jupiter* has been seen on three occasions in the present opposition, but it has not yet been found possible to measure it.

Dunsink Observatory.

The meridian circle and chronograph have been employed during the year in observing stars with large proper motions on the working list referred to in previous reports, to which early in the year the *Nautical Almanac* list of zodiacal stars was added at the request of Dr. Downing. Of these stars 365 observations of right ascension and 359 of declination have been made.

Since the end of June the necessity of pushing on with the reductions has diminished the number of observations, most of the observations since that date having been made for the purpose of duplication.

As they stand at present, all the observations, with very few exceptions, up to 1894 June have been reduced to mean place, and the work of bringing them up to catalogue form for the epoch 1890 is well in hand. The observations taken in 1889–90–91 in the intervals of other work (some of which had not even been written up from the chronograph sheets and observing notebooks owing to the smallness of the staff at this observatory) have been fully reduced during the year. This work, consisting of the places of over 600 stars, which have been credited with large proper motions, is at present in preparation for the press, and will shortly be published as the seventh part of the *Astronomical Observations and Researches made at Dunsink.*

As in recent years the standard stars of the *Berliner Jahrbuch* have been used for determining the clock corrections and the equator point of the circle, 405 right ascensions, including those of 78 close circumpolar stars for azimuth corrections, and 236 zenith distances of standard stars having been observed.

The level correction has been determined 171 times, the collimation correction 110 times, the nadir point (by reflexion) 92 times, and the correction for run 19 times. A new mercury-trough, with an amalgamated copper bottom on the principle of that used at the Oxford University Observatory, has been provided for observations of the nadir and of the collimation correction.

Very little work has been done with the "Roberts" 15-inch photographic equatorial, and that little consisted chiefly of visual observations for testing the performance of the clock. The difficulty of obtaining uniform motion, to which such frequent reference has been made, still, however, prevailed, notwithstanding some recent alterations; and all attempts at modification having failed, it was finally decided to replace the mounting by one of Sir Howard Grubb's latest patterns, designed specially for photography.

This is now almost completed, and will be an exact *replica* of the mounting which carries the Greenwich 13-inch photographic instrument, up to the cross head of the declination axis.

A new 18-foot dome for this instrument, consisting of a steel framework, covered with *papier mâché*, and furnished with a wide sector, opening beyond the zenith on Dr. Gill's principle, has been constructed and erected by Sir Howard Grubb during the year.

With the Troughton and Simms microscope 318 measures of photographs were made, mostly of photographs of the Dumbbell Nebula, taken at Mr. Wilson's Observatory in Westmeath. The results of these measures were published in the *Monthly Notices* for 1894 March.

With the "South" equatorial a small number (69) of micrometer observations, consisting generally of from four to six measures of position and a similar number of measures of distance, have been made. These include measures of a few of Otto Struve's double stars of Section II. vol. x. *Observations de Poulkova*; of the discs of *Jupiter* and *Saturn*; of standard distances in the clusters *Præsepe* and *h Persei* to determine the scale value of photographs; and of the position of Gale's Comet with reference to stars in its neighbourhood. The last have been published in the *Astronomische Nachrichten*.

There have also been 236 transits of stars observed with this instrument for determining the temperature correction of the Grubb micrometer.

On March 22 the "South" refractor and the 5-inch guiding telescope of the "Roberts" equatorial were used to observe the occultation of *α Virginis*, the results of which were published in the *Monthly Notices* for April.

The measures of *β Cygni* and *γ Andromedæ*, the results of which are incorporated in a paper in the *Monthly Notices* for 1895 January, "On the Effect of Atmospheric Dispersion on the Position of a Star," have also been made with this instrument.

Preparations were made for observing the transit of *Mercury* on Nov. 10, but clouds prevented anything being seen.

The time service has been maintained as in former years; and on the first Saturday of each month the observatory has been open to visitors, and the 12-inch "South" refractor placed at their disposal.

Glasgow Observatory.

In 1894 March the Trustees of the Bellahouston Bequest Fund made the generous grant of 1000*l.* to the Chair of Astronomy in the University, which is being employed in bringing the instruments at the observatory into efficient working order.

The 6-inch transit circle by Ertel is undergoing extensive alterations in Troughton and Simms' works: new piers have been built and the four old-roof shutters of the transit-room (which were of such a construction as, when opened, to cover half of the effective aperture of the slit) have been replaced by a single shutter, 31 feet in length, and running on pulleys. It is expected that the transit-circle will be ready for work by the beginning of April.

The 22-foot dome which houses the 20-inch "Breadalbane" reflector has been provided with two new shutters, and the Robinson's anemograph, formerly mounted on the top of this dome, has been erected on an iron lattice standard, such as is used for railway signal-posts.

It is noteworthy that the mounting of the reflector, made by Grubb in 1855, is of the same type as that employed for the photographic telescope at Potsdam. Sir Howard Grubb has been engaged in making a new 20-inch silver-on-glass mirror for this instrument. A large rigid platform firmly fixed to the declination axis and to the upper end of the tube will carry the various parts of a slit spectrograph of $3\frac{1}{2}$ inches aperture. One of the 60° prisms, $6\frac{1}{2}$ inches on a side, has already been supplied by Mr. Hilger.

The two sidereal clocks of the observatory have been removed into a large press with double walls, the spaces between which are filled with silicate cotton. In the course of weeks the temperature inside this press undergoes but slight variations, and, besides this, one of the clocks is kept in an air-tight case at a constant pressure of 27·0 inches. Both clocks can be switched to the Fuess chronograph.

It is worth mentioning that our novel mode of central field illumination has been most successfully adapted to the 3-inch transit instrument. The method may be thus described: a direct reflecting prism, $\frac{1}{2}$ inch on a side, is cemented to the outer surface of the object glass, and reflects the light from an electric lamp of 1 candle-power, which is firmly connected with the dew-cap at a distance of about 3 inches from the tube.

The time observations and the extensive meteorological work have been carried on as usual.

Liverpool Observatory.

The Liverpool Observatory exists mainly for the determination of time and its distribution to the Port of Liverpool, the rating and examination of chronometers deposited by makers and shipowners, and the maintenance of the series of meteorological observations. These duties have mainly occupied the attention of the small staff attached to the observatory. An alteration in the regulations made by the Dock Board has materially diminished the number of chronometers submitted for rating. Hitherto this work has been rendered free of charge to all engaged in the trade of the Port, but a small fee is now exacted, and the result has been that only one-half of the number of the marine chronometers usually sent to the Observatory has been deposited during the year.

An inquiry has recently been completed into the diurnal inequality of the barometric pressure as exhibited in the records obtained from the King's barograph, which has been continuously at work since 1867. The inequality has been derived for each month, and exhibits much the same features as those disclosed in the inquiry made at Greenwich from the observations 1854–1873. The general curve for the year can be represented by the expression

$$+0^{m}\cdot0010 \sin(\theta+63^{\circ}) + 0^{m}\cdot0086 \sin(2\theta+138^{\circ}).$$

The diurnal term is something smaller than that found at Greenwich. The angle in the semi-diurnal term indicates that the nodal point is passed about a quarter of an hour later at Liverpool than at Greenwich.

The result of an inquiry into the position of the Observatory has appeared in the *Monthly Notices*.

Attention is given to cometary observations; Denning's comet was observed as frequently as possible, and a fair series of Gale's was secured. These observations have also appeared in the *Notices*.

The courses of lectures on astronomy continue to be given under the auspices of the University College. Lectures have been given on spherical astronomy, to which has been added some practical work with the instruments, and in the present term lectures on meteorology are offered.

Radcliffe Observatory, Oxford.

The work of the staff during the past year has been chiefly directed to the completion of the Radcliffe catalogue of 6424 stars for the epoch 1890, which has now been published and distributed. In the formation of the Catalogue, the observed places have been carefully compared with the results of other Catalogues

for the determination of proper motions; but the determinations have not been generally used in the formation of the Catalogue, or printed, unless they were of sufficient magnitude to be of practical importance, and appeared to be determined with some close approximation to the truth. The observations above and below the pole have been discussed, and a careful comparison made with the places of the Cape Catalogue for 1880 to test the accuracy of the refractions used and the general agreement of both Catalogues. An independent determination of the epoch correction has also been made from a discussion of the Sun observations, and applied to the right ascensions of the Catalogue.

The Radcliffe Catalogue for 1890 and the Cape Catalogue for 1880 afford positions of all the stars in the Southern Hemisphere of not less than the seventh magnitude, except those in clusters, and of fainter stars in those portions of the sky where there are no stars so bright as the seventh magnitude.

The opportunity afforded by the completion of the observations required for the Catalogue was utilised for a general cleaning and overhaul of the transit circle instrument; and a new clamp and slow-motion have been supplied by Mr. Simms.

The observing with the transit circle during the past year has been confined to the observations of the Moon, of a few stars whose place appeared to require further observation, and of comparison stars required for comet observations.

The Barclay equatorial has been employed in miscellaneous observations of *Nova Aurigæ*, *Mars*, and comets.

During the visit of the British Association to Oxford the Observatory was thrown open to members and associates, and a large number availed themselves of the opportunity of visiting the Observatory.

The meteorological work has been regularly carried on, and any information required by engineers and others for practical use has been supplied on demand.

University Observatory, Oxford.

The chief astronomical work accomplished in the year 1894 has been experimental work on the methods of measuring and reducing the plates for the Astrographic Chart. As a preliminary the work initiated by the late Professor Pritchard, of measuring several plates of the *Pleiades* (mentioned in the last report), was completed to a definite stage, and the results have been communicated to the Society (*Monthly Notices*, vol. liv. page 489). The method of rectilinear coordinates was introduced into the reductions and found completely satisfactory, both in accuracy and in great saving of labour. Attention was then directed to the particular problems of the work for the Astrographic Chart. A new micrometer of simple pattern, and with a scale instead of a micrometer screw, was constructed by Messrs. Troughton and

Simms, and received in 1894 October. Meanwhile a microscope and scale was furnished by the same firm for use with a rough wooden apparatus which had served as a model for a similar instrument. Six plates have been completely measured with the rough apparatus or the finished micrometer, and it is found that satisfactory measures can be obtained at the rate of 50 stars an hour, and that these measures may be reduced quickly and simply. It is the settlement of the best processes for attaining this end of simple and rapid reduction which has chiefly occupied the time of the observatory. An exposition of the method finally determined upon is now ready for communication to the Society.*

The number of plates taken for the Astrographic Chart has been few, partly on account of bad weather and partly because the Director, on his appointment in 1893 December, found the astrographic dome so urgently in need of repair that work with the instrument had to be temporarily given up. The repairs on the dome were not completed until 1894 June. Several other instruments have required repair.

Lectures on general astronomy in the Trinity and Michaelmas terms were attended by fifteen to twenty students, two or three of whom have done practical work at the observatory. With a view to teaching the use of a small transit-circle indoors and in the daytime, an apparatus, which may be called an "artificial sky," has been fitted on the roof of the lecture-room. This apparatus, devised by the Director in concert with Mr. Simms, rotates uniformly round a pivot, and carries both equatorial and polar artificial stars; and a small altazimuth (kindly presented to the observatory by Mr. Ernest De la Rue), mounted below on a solid brick pier, can thus be adjusted, not only for collimation and level, but for azimuth, and the clock-error found. The observations hitherto made with this apparatus have been found satisfactory.

The transit of *Mercury* on 1894 November 10 was observed at Sidmouth by the Director.

The scales of the three photometric wedges belonging to the observatory have been redetermined by Captain Abney.

During the visit of the British Association to Oxford, the Observatory was thrown open to members and associates, and a large number availed themselves of the opportunity.

The constitution of the staff remains as in the last report.

Temple Observatory, Rugby.

The educational work of the observatory has been continued as usual, a certain time every fine evening being given up to members of the school. The original work has consisted almost wholly of obtaining measures of double stars, but a few photographs of stellar spectra have been tentatively taken.

* See *Monhtly Notices*, vol. lv. p. 102.

Stonyhurst College Observatory.

The meteorological and magnetical work of the observatory has been carried on as usual.

As yet no regular work has been commenced with the Father Perry Memorial Objective. On all the clear nights of the year it has been employed upon a series of experiments in stellar spectro-photography, the leading object being to decide upon the most serviceable form of spectrograph that would suit the equatorial in its new condition under the extra load of the 15-inch objective and its adapting tubes. These experiments, including two months' work with a fine 8-inch disc-prism, kindly lent by Mr. Hilger, will form the subject of a future paper, if the final results prove to be of sufficient interest.

Dr. Common's Observatory, Ealing.

The experiments made with a view of getting a more convenient form of large reflecting telescope mentioned in last year's report have occupied nearly the whole of last year's available working time, and have been brought to a successful conclusion in the form of an Oblique Cassegrain telescope, particulars of which have been laid before the Society.

In the course of these experiments some thirty convex mirrors, from 3 inches to 15 inches diameter, have been made and remade, and one 30 inches concave. The stage for use with the 5-foot has been taken down, and the 5-foot has been temporarily converted into a smaller telescope on the Oblique Cassegrain plan.

Mr. Crossley's Observatory, Bermerside, Halifax.

As in past years the work of this observatory has been chiefly the observations of the phenomena of *Jupiter's* satellites, and of the occultations of stars by the Moon. Meteorological observations are taken twice daily, and reports sent to the Registrar-General, Mr. Symons, and one of the local papers.

Wolsingham Observatory. (Rev. T. E. Espin.)

The total number of objects observed during the year is 1044. Besides the observation with the spectroscope of objects already known, 92 stars of Type III.!!!, III.!! or IV. have been detected, 100 of Type III.!, 276 of III. Sixty stars are under observation for variation. Variations in the following stars have been discovered or confirmed :

Name.	R.A.(1900) h m	Decl. (1900) ° ′	Var.	Type.
D.M. +62°.161	0 45·3	+62 23	8·7 to ?	III.!!!
Es-Birm. 13	0 49·0	+58 1	8·6 „ 10·5	IV.?
Anonymous	1 49·7	+58 46	9·3 „ 10·8	IV.?
D.M. +54°.622	2 49·6	+54 15	8·9 „ 9·6	III.?
D.M. +50°.2251	16 1·5	+50 47	7·8 „ 8·9	IV.?
Anonymous	17 54·9	+58 14	8·0 „ ?	IV.
Anonymous	19 16·9	+37 41	8·3 „ 10·3	IV.!

Dr. Huggins' Observatory, Upper Tulse Hill.

During the earlier part of the year much time was occupied in the completion and the final adjustments of the new spectroscopic apparatus.

Work on the spectrum of the *Orion* and other nebulæ by photography was commenced in the autumn, and as much progress as was possible, considering the unfavourable weather, has been made in obtaining photographic spectra of the nebula, and of the stars apparently involved in it.

The question as to the reality of the atmospheric bands observed by Dr. Huggins in the spectrum of *Mars* during the years 1862–67 having been raised by observations made on the planet at the Lick Observatory, the photographic work was interrupted for a short time in November for the purpose of repeating those early comparisons of the spectrum of *Mars* with that of the Moon at similar altitudes, with the more modern spectroscopes now attached respectively to the refractor and to the reflector, mounted on the Tulse Hill equatorial. Visual observations were made with the former, and photographs of the spectrum of the Moon and of *Mars* were taken with the reflector, which extend as far as S in the ultra violet.

The results confirm Dr. Huggins' early observations that under similar conditions of altitude, and even when the Moon is lower than *Mars*, some atmospheric bands near D were distinctly stronger in *Mars*; while in the part of the spectrum more refrangible than F, no indications of atmospheric absorption, as had already been shown by Dr. Huggins in 1879, could be detected in the photographs. In addition to the indications of planetary absorption, at, and on the red side of D, a dark band was observed on some nights on the blue side of D, beginning at the stronger end at about λ 5860, and traceable to beyond λ 5840. It is suspected that this band may belong to the atmosphere of *Mars*, and may be variable, possibly in accordance with conditions prevailing on the planet.

Rousdon Observatory, Lyme Regis. (Mr. Peek.)

The establishment continues in good working order, and observations have been made on 160 nights, this being about the average number.

The 6·4-inch Merz achromatic telescope has been regularly employed on long period variable stars, and 511 determinations of magnitude have been secured. Special attention has been given to S *Coronæ*, S *Herculis*, and R *Cygni*. Each of these stars when passing the minimum phase has exhibited the phenomenon of a very minute stellar point, disappearing, and leaving its position occupied by a very faint bluish nebulous haze. Since the work commenced in 1885 December, thirty long-period variables have been observed, and 141 maxima and 121 minima have been determined.

All variables on the working list are observed at least twice monthly throughout the whole of their periods, and not merely at maximum and minimum.

Transit observations have been taken as often as required.

Gale's Comet was observed on twelve nights between May 4 and July 14; for the first week it was distinctly visible to the naked eye. Encke's Comet was viewed on November 25, when it was excessively faint: it has since become easily visible in small telescopes.

The ingress of *Mercury* at the transit on November 10 was observed under most favourable conditions, and the times of external and internal contact at ingress noted. There was no trace of any white spot, nor of any ring or halo round the planet, and during the twenty-five minutes it could be observed it appeared as a very black, circular, well-defined disc.

Dr. Isaac Roberts' Observatory, Crowborough Hill, Sussex.

The photographic work at this observatory has been maintained during 1894 on the same plan as in preceding years, but the number of really first-class nights has been somewhat below the average.

The following list of photographs of nebulæ and clusters shows the longer exposures taken, and is in continuation of that published in the *Monthly Notices*, vol. liv. pp. 229, 230.

	R.A. h m	Decl. ° ′	Expos. m
Great Nebula in Andromeda	0 36	+40 30	90 (2 photos)
Neb. H I. 112 Arietis	1 53	+18 30	90
Neb. H I. 101 Ceti	1 54	− 6 29	38 90
Neb. H I. 154 Persei	2 24	+36 40	90
Neb. H I. 63 Eridani	2 36	− 8 41	39
Nebulæ in Pleiades	3 40	+23 46	720

(On 1893 Dec. 30, 1894 Jan. 2, 6, and 7)

	R.A. h m	Decl. ° ′	Expos. m
Neb ℍ I. 217 Aurigæ	4 23	+35 3	180
Great Nebula in Orion	5 30	− 5 27	60 (2 photos)
„ „ (on Feb. 3 and 8)			455
Neb. M. 78 Orionis	5 41	+ 0 1	44 and 3h
Cl. M. 46 and Neb. ℍ IV. 39 Argûs	7 37	−14 30	90
Cl. ℍ VI. 37 Argûs	7 55	−10 20	90
Neb. M. 65, 66 and ℍ V. 8 Leonis	11 14	+13 50	220
Neb. ℍ I. 19 Comæ Berenicis	12 4	+19 8	110
Neb. M. 98 Virginis	12 8	+15 29	240
Neb. ℍ I. 75, 89, 90 Comæ Ber.	12 14	+29 30	90
Neb. ℍ I. 77 Comæ Berenicis	12 21	+31 48	65
Neb. ℍ I. 31 Virginis	12 28	+ 8 17	90
Neb. ℍ I. 83 and V. 24 Comæ B.	12 28	+26 28	90
Neb. ℍ V. 2 Virginis	12 29	+ 2 46	90 and 180m
Neb. ℍ V. 24 Comæ Ber.	12 31	+26 34	180
Neb. ℍ I. 92 Comæ Ber.	12 31	+28 43	105 and 120m
Neb. ℍ I. 178, 179 Canum V.	12 36	+41 44	90
Neb. ℍ V. 42 & I. 176, 177 Comæ B.	12 38	+32 55	90 and 3h
Neb. ℍ I. 39 Virginis	12 43	− 5 14	90
Neb. ℍ I. 129 Virginis	12 43	− 8 8	65
Neb. ℍ I. 84 Comæ Berenicis	12 45	+26 5	90
Neb. ℍ I. 143 Virginis	12 55	+ 3 4	90 and 3h
Neb. ℍ I. 130 Virginis	13 0	− 7 27	90
Neb. ℍ I. 190, 191 Boötis	13 54	+37 57	54
Neb. ℍ I. 99 Bcötis	14 14	+37 0	90
Neb. ℍ I. 144, 146 Virginis	14 15	+ 4 6	90
Neb. ℍ I. 182 Virginis	14 34	+ 0 10	90
Neb. ℍ I. 126 Virginis	14 39	+ 2 24	54
Neb. ℍ I. 127, 128 Libræ	14 58	+ 2 4	77
Neb. ℍ II. 751, 752 Boötis	15 2	+20 0	56
Neb. ℍ I. 148 Serpentis	15 16	+ 5 27	90
Cl. M. 16 Clypei	18 13	−13 50	60
Cl. *h* 2017 Aquilæ	18 36	− 4 52	60
Cl. *h* 2018 Aquilæ	18 36	− 6 20	60
Stars in Cygnus	19 45	+35 30	60 (2 photos)
Cl. ℍ VIII. 20 Cygni	20 7	+26 11	50
Cl. ℍ VI. 42 & Neb. ℍ IV. 76 Cephei	20 31	+60 3	60
Cl. ℍ VII. 53 Lacertæ	22 1	+45 57	60
Cls. *h* 2159, 2161 Cephei	22 19	+57 26	60

Beside the foregoing a number of shorter exposures have been taken, including such objects as Denning's Comet (exp. 45^m), March 29; Gale's Comet (exp. 15^m), May 7; Encke's Comet (exp. 30^m), December 18; occultation of *Spica*, March 22, &c. Enlarged copies of some nebulæ and clusters named in the list have been presented to the Society, and lantern slides of the same exhibited at the meetings.

The work entitled "A Selection of Photographs of Stars, Star-clusters, and Nebulæ," which was alluded to in the preceding report as being in preparation, has been published by Messrs. Witherby & Co., and is now available to those interested in the study of celestial photography.

Some considerable portion of the autumn months was occupied in testing the new triple objective of 6-inch aperture, made by Messrs. T. Cooke & Sons. The lens proved to be *perfectly* "achromatic," no trace of secondary colour being visible around even the brightest objects. The visual and photographic foci were found, from a great number of careful experiments, to be exactly coincident, as in a reflector.

Mr. Wilson's Observatory, Streete, Westmeath.

During the past year the 24-inch reflector was principally used for photographic purposes, and some very satisfactory negatives of clusters and nebulæ were taken. The large heliostat was used in the experiments on the radiation from sun-spots, and the results will shortly be published. The weather has been very cloudy, and the number of good nights very few and far between. A 4-inch photographic telescope was ordered from Sir H. Grubb for taking solar photographs, but it arrived too late in the year to do any work with it.

Hongkong Observatory.

The time service and transit observations of the Moon and planets have been continued as usual. Absolute magnetic observations have been made regularly. Hourly meteorological observations have been continued without interruption. The main object of this observatory is marine meteorology, investigations of typhoons, and storm-warnings. During the absence of the Director in summer and autumn Mr. Plummer took charge of the astronomical observations, Mr. Figg took charge of meteorological work and storm-warnings, and Miss Doberck attended to marine meteorology. During his leave of absence the Director was engaged in a redetermination of the orbit of the first comet, of 1824, observed by Sir T. M. Brisbane in Queensland. The Lee equatorial was remounted on granite piers last spring, but unfortunately the dome

was blown away during a typhoon in the autumn, as it had not been sufficiently secured by the iron bolts which were supplied for the purpose.

Madras Observatory.

During 1894 the work of reducing and printing the old observations was carried on as rapidly as possible, and vol. viii. of the *Meridian Circle Observations* was received from the press at the close of the year. This completes the series of preliminary volumes, and leaves (for this part of the work) only the General Catalogue, with which considerable progress has been made.

The investigation of the circle errors has been taken in hand, and the reduction of all the observations of circumpolar stars for the determination of the latitude correction is far advanced.

The time service and meteorological records were maintained as in former years. Observations were made of the two solar eclipses, of Z *Herculis*, and of several comets.

Much of the time of the Government astronomer has been taken up with questions connected with the new observatory at Kodaikanal, and matters have advanced so far that building operations will probably be begun within the next three months.

Melbourne Observatory.

During the past year the work at this observatory has been somewhat curtailed owing to the necessity for continued retrenchment in the public service of the colony. The routine work in connection with time distribution, meteorology, terrestrial magnetism, has, however, been regularly continued as heretofore, but many minor changes for the lessening of clerical work have been adopted. Meridian observations have also been carried on as usual, and the work done up to the end of November comprises the observation of 2379 stars in R.A., and 1226 in N.P.D., including the determination of the positions of 446 stars selected from the astrographic catalogue plates for use in the final measurements.

The astrographic work on the Melbourne zones (65° to 90° S.) has been steadily proceeded with ; the weather, however, has been remarkably unfavourable for the undertaking, and as no photographs are obtained except on really good nights, the number of plates secured during the year was only 368, comprising 290 catalogue, 17 chart, and 61 type plates. One of the *réseaux* ruled on plates coated with asphalt varnish, referred to in last year's " Proceedings of Observatories," has been in continual use throughout the year, and has been found very satisfactory. Those ruled on plates coated lightly with Blundell and Spence's

Brunswick Black stand the test, and show no signs of "flaking" or "pinholes" after a year's work.

Some further pendulum observations were made in July, August, and September. A set of half-seconds pendulums, somewhat like those of Colonel von Sterneck, having been constructed, determinations of their constants were undertaken, as well as a series of observations for the value of g by means of them by Mr. P. Baracchi, chief assistant, and Mr. E. F. J. Love, M.A., Lecturer in Physics at the Melbourne University. In September Mr. Love took these pendulums to England, intending to swing them at Kew or Greenwich, and probably at the Cape also, on his return voyage to Melbourne. It is hoped that these observations will furnish information as to the value of small pendulums for determining differences of g at different parts of Australia, and also a further trustworthy determination of the difference of g between Kew, the Cape, and Melbourne.

Scarcely any extra-meridian work has been done, and beyond a few comet places, and an occasional astronomical occurrence, there is nothing to record.

The great telescope was laid up during the winter months for repair and cleaning ; the mirrors now in use are in good condition and perform satisfactorily. A new secondary mirror of silvered glass was made during the winter, and the metal ones repolished. At the request of Mr. Pickering, *Mars* was carefully watched in May and June with this telescope, and the changes of the south polar cap observed during these months. It is intended to try this telescope for some photographs during the summer months, but it can only be used for moderately short exposures, as it is impossible to drive it steadily for any length of time unless in a dead calm.

Sydney Observatory.

No change in the staff has been made since the 1893 report. Additional workers are urgently needed, but in the present depressed times there is no hope of increasing the staff.

Transit Circle.—The weather during 1894 for the months January to October inclusive has been rather better than usual, but for November and December it has been very bad. Counting as fine nights those wholly fine and those fine for an hour or two, we have had 145 nights on which observations and photographs could be made.

During the year 1481 transits have been observed by Mr. Lenehan, of these 457 were of the Sun's limb for public time, and 283 clock stars ; 741 transits of the reference stars of our zone were observed, and 713 in N.P.D.

The error of Azimuth was determined 91 times ; Collimation, 298 ; Level, 381 ; Nadir, 375.

The stars observed in 1892 are ready for the press. The computations of those for 1893 are almost completed, and those for 1894

in a forward state. The observation of guide stars for the centres of the photographic plates is well forward, and another catalogue, giving a reference star in each quadrant of each plate, is in course of preparation and observation. No longitude or other work outside the stars for our zone has been done with the transit circle. Through the courtesy of Dr. Hay, the new proprietor of the property on which our N. meridian mark stands, the trees which have for some years covered the mark have been removed, and it is now quite clear and useful for some purposes: it is distant $1\frac{3}{4}$ mile and 340 feet above the sea.

Equatorial.—Ninety-five nights (exclusive of Sundays) have been fine enough for work with this instrument. Of these nights forty-eight were devoted to measuring double stars, fourteen to comet observations, twenty to visitors; on eleven the definition was so bad no measures could be taken, and on two Mr. Sellars was at work with the transit circle.

No new double stars have been added to the list. Fifty-three pairs of stars have been measured 100 times, involving 400 sittings for position angles, and 380 for determination of distance. All the measures are reduced and ready for publication.

Comet Gale was compared with sixteen catalogue stars ninety-nine times.

The double-star results of 1892 and 1893 have been published in *Ast. Nachr.* No. 3240. Some of the comet observations were published in *Ast. Nachr.* No. 3255, and the complete set in *Monthly Notices*, vol. liv. No. 8.

Mars in opposition was regularly observed, but nothing worthy of special note was seen.

Photographic Work.—There were fine or partially fine 145 nights, not quite so many as in 1893, but a much larger number of plates were taken, the difference being due to two causes: First, there were more nights fine right through; and second, and chiefly, because the plates used would record a good image of an 11 magnitude star in one minute. The total number of catalogue plates obtained was 876, thus leaving only 70 plates to complete the Sydney zone. These would have been easily taken in November and December with ordinary weather.

Guide stars have been selected and observed for four positions in which the catalogues contained no stars. We hope to complete our catalogue plates this month. No chart plates have been taken. Nine plates were taken of Comet Gale, 53 for parallax, 79 to investigate certain nebulæ and clusters of stars, and 53 test plates, making in all 1070.

In 1891 the best plates we could obtain required an exposure of eight minutes to record an eleventh magnitude star by our present plate maker (Marion). This time has been gradually reduced to one minute on the plates we are now using. A great deal of time has been given to experiments in star measuring, and the form of micrometer proposed by Professor H. H. Turner has been adopted.

Meteorology.—The general meteorological service has been actively maintained, and the number of observers increased to 1278. The volume of rain and river results for 1893 has been printed and published.

The weather chart service, with two issues daily and two forecasts, has been actively maintained and improved.

General.—There have been received from other observatories and publishers, in exchange for our publications, 940 volumes and pamphlets; our publications to the number of 3500 have been sent out.

Visitors to the observatory continue to increase, and are becoming a very serious charge upon our time. 217 persons have called to consult upon scientific matters, 830 persons have called to see the observatory, and 97 have applied by letter for information, which has involved twenty-eight days' work to supply. This is a serious but unavoidable demand upon our time.

In January Mr. Love, Demonstrator in Physics in Melbourne University, acting for the Gravity Committee of the Royal Society of Victoria, brought here, in pursuance of the work undertaken, the original Kater invariable pendulums, and they were swung in exactly the same place they occupied in 1882 January. In May an Austrian man-of-war arrived with another set of half-seconds pendulums for gravity observations, and these also were swung in the same part of the observatory cellar.

A number of experiments have been made to determine the amplitude of vibration of stars in times of bad definition, one small star with an estimated diameter of $1\frac{1}{2}$ inch vibrated $4\frac{1}{2}$ seconds, that is from wire to wire set $7\frac{1}{2}$ inches apart.

The transit of *Mercury* (egress) was observed, and result published.

The 10-foot standard bar of Queensland has been very carefully compared with the two 10-foot standard bars of New South Wales; all three steel tapes used in the Queensland trigonometrical survey have been compared with our standard 10-foot bars.

On October 26 Messrs. Ellery, Todd, and Russell met in conference in Melbourne in furtherance of their astronomical and meteorological work.

A chart of southern circumpolar stars, designed for the convenience of surveyors and amateur astronomers, has been prepared in the observatory. It is accurately made, and much clearer than existing south circumpolar charts. It is 30 inches in diameter, and includes all stars to $6\frac{1}{2}$ magnitude.

In 1893 December Parliament passed an Act providing that "the mean time of the one hundredth and fiftieth meridian of longitude east of Greenwich in England shall be deemed and is hereby declared to be standard time throughout New South Wales." This comes into operation on 1895 February 1.

Mr. Tebbutt's Observatory, the Peninsula, Windsor, New South Wales.

It will be seen from the following summary that the results accomplished at this observatory during the year 1894, though of considerable importance, are not so abundant as usual. The rule hitherto has been to determine the local sidereal time as often as the weather or the observer's avocations permitted, but the determination of time during the past year has been confined almost wholly to those nights on which extra-meridian observations were made. Transits were accordingly observed on seventy-nine nights, the number, exclusive of stars in high south declination for azimuth, being 450. The separate determinations for level, collimation and azimuth were 203, 33, and 81 respectively. It was three times found necessary to adjust for level error, but no adjustment was made for either collimation or azimuth. The rate of the sidereal chronometer has been found satisfactory.

With the 8- and $4\frac{1}{2}$-inch equatorials, twenty-six disappearances of stars were observed at the Moon's dark, and six at the bright limb, and eight reappearances at the dark and the same number at the bright limb : altogether forty-eight phases. Ten *Nautical Almanac* stars were observed in both phases, including an occultation of *Antares* on October 31. The disappearance in this case occurred in full sunlight, and the reappearance in strong twilight. The observations of the daylight occultations of *Spica* and *Antares*, on November 24 and December 24 respectively, were unsuccessful in consequence of dense smoke from bush fires in the former case, and cloud in the latter. An excellent observation of the disappearance of *Venus* at the bright limb was made on May 1. Messrs. Innes and Brooks, Fs.R.A.S., have kindly supplied the observatory with prediction calculations of occultation phenomena.

On the morning of April 3, civil time, a notification was received from Mr. Walter F. Gale, of Paddington, of his discovery of a comet (Comet II. 1894), and observations were obtained here on the evening of the same day. The resulting place, with the discoverer's name and the date of discovery, was telegraphed the next day to the Melbourne Observatory. The weather was remarkably favourable for the observation of the comet, and excellent positions were obtained here on twenty-seven evenings, from April 3 to May 11. A determination of the orbit was also published, based on the extreme and middle observations of the series, and it was found to agree very closely with that derived by Herr Kohlschütter, of Kiel, from the Windsor observation of April 6, and Cape and European positions extending to May 9. At the request of Dr. Schulhof, an attempt was made to follow the periodical comet of Tempel 1873

II., at its recent return to perihelion, but in consequence of the extreme faintness of this object only one observation of any value could be secured. Encke's comet was picked up with the $4\frac{1}{2}$-inch equatorial on December 20, but it was low, and the weather turned out very unfavourable. It will probably be better observed in the morning sky in February next.

The following interesting southern double stars were measured with the 8-inch equatorial during the last three months of the year: β and ζ *Phœnicis*, κ *Toucani*, *h* 3447, *p Eridani*, *h* 3592, *Lacaille* 2145, α *Centauri*, γ *Coronæ Australis*, *Lacaille* 8550, *h* $5295\frac{2}{3}$.

The usual meteorological observations have also been regularly made, the past year being the thirty-second since the establishment of this department of observation. All the astronomical, and about ninety per cent. of the meteorological observations, and by far the greater portion of the reductions, both astronomical and meteorological, have been made by the proprietor himself.

Notes on some Points Connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1894.

Twenty-three new planets were discovered during the past year, as follows :—

Provisional Designation.	Permanent Number.	Date of Discovery, 1894.	Discoverer.	Place of Discovery.
AQ	379	Jan. 8	Charlois	Nice
AR	380	8	,,	,,
AS	381	10	,,	,,
AT	382	29	,,	,,
AU	383	29	,,	,,
AV	384	Feb. 11	Courty	Bordeaux
AW	...	Jan. 30	Wilson	Northfield, Minn.
AX	385	Mar. 1	Wolf	Heidelberg
AY	386	1	,,	,,
AZ	387	5	Courty	Bordeaux
BA	388	7	Charlois	Nice
BB	389	8	,,	,,
BC	390	24	Bigourdan	Paris
BD		Nov. 1	Wolf	Heidelberg
BE		1	,,	,,
BF		7	,,	,,
BG		7	,,	,,
BH		19	Borelly	Marseilles
BK		30	Charlois	Nice
BL		Dec. 1	,,	,,
BM		19	,,	,,
BN		28	,,	,,
BO		Apr. 9	Roberts	Crowborough

The letter BI was assigned to a planet discovered by Charlois on November 24, which was subsequently found to be identical with No. 369. AW and BO were discovered on photographs

taken for other purposes than the discovery of planets, the first being on a photograph of the *Pleiades* and the second on a photograph of the nebula $\frac{H}{I}$ I 143.

Only one planet has received a name since the date of the last report, viz. No. 321, which has been named *Florentina*. An error in the last Report may be noticed here: the name of No. 316 should be *Goberta*, not *Roberta*, the latter being the name of No. 335, as given in the Report for the previous year.

The number 359 has been assigned to 1893 M, discovered by Charlois 1893 March 10.

The planet BE has an interesting orbit, its perihelion distance (1·60) being the smallest of the entire family, with the possible exception of 323 *Brucia*. Its least distances from the orbits of the Earth and *Mars* are about 63 and 21 millions of miles respectively. This planet is therefore well adapted for determining the Solar Parallax.

The planet No. 387 will be of about the 7th magnitude in favourable oppositions. No. 388 must have been close to 1892 S when the latter was discovered in 1892 December. The two planets, however, are not identical.

None of the nine missing planets enumerated in the last Report have been picked up. In addition to these, the following fourteen planets discovered in 1890 and 1891 have not been seen at any subsequent opposition :—Nos. 290, 293, 296, 307, 309, 310, 314, 315, 316, 318, 319, 320, 322, 323.

Professor Barnard has measured during the past year the diameters of *Ceres*, *Pallas*, and *Vesta* with the 36-inch equatorial at Mount Hamilton. His results have been already given in the *Monthly Notices* (vol. liv. No. 9). The diameters come out :—*Ceres* 520 miles, *Pallas* 304 miles, *Vesta* 241 miles. The great excess in size of *Ceres* over *Vesta* is surprising, and the latter planet must have a high albedo to account for its relative brilliancy. A. C. D. C.

Comets of 1894.

The following comets have been discovered in 1894, and on some grounds are more than usually interesting.

Comet *a* 1894, by Denning.
Comet *b* 1894, by Gale.
Tempel_2 1873, by Finlay.
Encke, by Perrotin, Wolf, Cerulli.
Comet *e* 1894, by E. Swift.

The first of these, discovered on March 26 in the constellation *Leo Minor*, was a faint object, and unfortunately growing fainter. The perihelion passage occurred about February 9, and the comet was increasing its distance from both Sun and Earth, so that notwithstanding a favourable position in the sky for ob-

servation, it has been somewhat inadequately observed. This is the more to be regretted, since the orbit is very interesting. Its ellipticity was early noted, though the period remained somewhat doubtful, and definitive elements are still wanting. From his first elements, M. Schulhof, pointed out that the orbit made a close approach, less than one-fifth of the Earth's distance from the Sun, to the orbit of *Jupiter*, in Hel. Long. 287°, and that in 1889 the two bodies had made a close approach. Further, that Tisserand's well-known criterion was satisfied in the case of two imperfectly observed comets—viz., 1743, I., and 1819, IV.—and the present comet. Later, M. Schulhof called attention to the fact that the point of closest approach between the orbits of *Jupiter* and the comet coincided very approximately with that of *Jupiter* and Brorsen's comet, and this fact has been further emphasised by Dr. Hind, who shows that the two comets, Denning and Brorsen, were actually near each other in 1881 April. Dr. Lamp, to whom we are indebted for the most accurate investigation of Brorsen's comet, shows that the two orbits intersect in Long. 284° 47′ and South Latitude 1°·57′, and that this point was passed by Brorsen on 1881, February 7, and by Denning 1881, March 14. This latter date depends on Schulhof's elements, which are still somewhat doubtful, and to secure the closest possible approach it would be necessary to diminish the mean daily motion found by Schulhof some 28″. This alteration seems large, implying as it does an error in the period of nearly half a year, but between the orbits of Schulhof and Hind there exists a still greater difference. M. Schulhof has employed an observation on May 22, while Dr. Hind's orbit rests on positions prior to May 6 ; this fact shows the importance of observations being continued as long as possible, but the Nice observation on June 5 appears to be the last.

For the second comet we are indebted to the energy of Mr. Gale, an amateur astronomer of New South Wales, and the discovery is an encouragement to all who work with small instruments, for Mr. Gale writes that he detected it with a 3-inch telescope. The comet was observed for a month at Windsor, N.S.W., Melbourne, &c., before it became visible in Europe, when, having reached its greatest brilliancy, it was a fairly conspicuous object in our western skies. A photograph taken at Paris on May 5, showed a tail 4° long, but the most complete study of its general features was made by Mr. Barnard at the Lick Observatory. A full account, with an admirable reproduction of one of the plates, appears in *Astronomy and Astro-Physics* for 1894 June. In the spectrum, which resembled that of the bright comet of 1893 (Rordame-Quénisset) more than twenty lines could be traced. The orbit shows no deviation from the parabola.

Tempel$_2$ 1873 comet, at its recent return was very unfortunately situated for observers in the Northern Hemisphere, rising about two hours before the Sun. More fortunately situated in the Southern Hemisphere, Mr. Finlay, of the Cape of

Good Hope Observatory, succeeded in finding it on May 8 by the aid of the ephemeris provided by M. Schulhof. The error in the assigned position was only nine seconds of right ascension and thirty seconds in declination, implying an increase of the mean anomaly of only 51″, a result upon which M. Schulhof may be congratulated, more especially when we remember that the comet has not been observed since 1878. The number of observations made at the Cape, at Windsor, N.S.W., and elsewhere is very few, owing to bad weather and the faintness of the comet, but the recovery of the comet after sixteen years is most satisfactory.

Encke's comet at its recent return was independently discovered by, at least, three observers. M. Perrotin at Nice obtained an observation on October 31 with the great equatorial, and described the comet as at the extreme limit of visibility in that telescope. On the same evening M. Wolf, at Heidelberg, secured a photographic record of the presence of the comet, but could not make any accurate determination of place. Dr. Cerulli, in Teramo, also saw the comet on November 1 as a faint nebulous object, but did not record the place with accuracy. These astronomers were assisted by the excellent ephemeris of Dr. Backlund, whose elaborate calculations on the motion of this comet have been highly appreciated, and whose intended withdrawal after his long supervision has been heard with so much regret. Not less valuable than the preparation of the ephemerides at each return of the comet is his determination of the mass of *Mercury* from the perturbations of this comet. In 1891, an approach to that planet was made, and the result of the discussion of the long series of observations has been to give a value, the most trustworthy, if the smallest, which has yet been assigned. This comet is still under observations and will be followed for some time longer in the southern hemisphere.

The last comet to be discovered was a very faint object, first seen on November 21 by Mr. E. Swift, of the Lowe Observatory, California (whither the Rochester Observatory has been removed). The comet was very faint, and like Denning's, had passed its perihelion, and was growing fainter. It had a considerable southern declination, but with northern motion; this advantage was, however, diminished by the growing faintness of the comet. Almost concurrently with the announcement of the discovery Dr. Berberich suggested the identity of the comet with the lost *De Vico*, and further examination and calculation support the suggestion. The arguments in favour of the identity are: the increase in the longitude of the perihelion and the decrease of that of the node, results which must follow the perturbation of a comet of short period with direct motion; the satisfaction of the Tisserand criterion; and the fact that both comets, supposing them to be distinct, were, according to the elements of Brünnow and Schulhof, respectively, in the neighbourhood of *Jupiter* in 1885, and that an increase in the period, such as that indicated, is likely

to result from the perturbations. It is to be hoped that the observations will be sufficiently numerous to permit a rigorous determination of the orbit, and the decision of this interesting question. So many comets have exhibited unexpected increase of brilliancy, notably that of Holmes, that it occasions less surprise that a comet should remain invisible for fifty years and once again become a recognisable member of the system.

In addition to these it may be mentioned that an object photographed during the solar eclipse of 1893 April 16, has in the last year been generally recognised as a comet. This fact recalls the observation made under similar circumstances in May, 1882, at Sohag, and suggests that many comets pass through their perihelia without being detected.

W. E. P.

Progress of Meteoric Astronomy in 1894.

January Meteors.—At the epoch of the return of the *Quadrantids*, early in 1894 January, a very intense frost prevailed over England, and not many shooting stars were observed. A few were, however, recorded by Professor Herschel, at Slough, Mr. Corder, at Bridgwater, and Mr. Denning at Bristol. On January 2, at about 7^h, Mr. Corder found the *Quadrantids* very active for a short time, the rate of apparition being about 40 or 50 per hour. He determined the radiant as at $219°+53°$ from 14 meteors, and found a neighbouring radiant in *Hercules* at $240°+48°$. A meteor of about second magnitude from the latter position was mapped both at Slough and Bridgwater on January 2 at $9^h\ 40^m$. It fell from a height of 65 miles above Cirencester, Glos., to 56 miles above Cranborne, Dorset, and traversed a real path of 53 miles with a velocity of about 21 miles per second.

April Meteors.—The moon was full on the 20th, and prevented successful observation. Mr. Corder watched for an hour on the 22nd with no result, and on the 23rd saw only 4 meteors in two hours. The only conspicuous *Lyrid* recorded at Bristol appeared on April 22, $9^h\ 59^m$, shooting from $260°+59°$ to $243°+72°$, and leaving a bright streak.

May Meteors.—On the mornings of May 1, 2, 4, 6, 7, and 10 Professor Herschel made a series of observations with a view to redetecting the fine shower of *Aquarids* discovered by Lieut.-Colonel Tupman in 1869. About 11 meteors of this system were mapped, but indicated a radiant not very sharply defined. Contemporary showers manifested themselves from the points $309°-17°$, $245°-20°$, $227°+47°$, and $25°+25°$.

August Meteors.—In the *Comptes Rendus*, 1894, No. 12, Padre F. Denza gave a summary of observations of shooting stars at 24 stations in Italy on the nights of August 9, 10, 11, and 12, the total number seen on the four dates being 1805, 5226, 2468,

2336 respectively, making an aggregate of 11835. At one of the stations, Montevergine, 4500 feet high, a fine display of *Perseids* was witnessed on the morning of August 11 at about 3 A.M., when shooting stars fell so plentifully that the exact number could not be counted. The chief position for the *Perseid* radiant, as determined at the Vatican Observatory, was at 45°+54°, and minor showers revealed themselves in *Cassiopeia*, *Draco*, and *Cygnus*.

At Utrecht Messrs. Nyland and Bolt noted 23 meteors within the 50 minutes from $12^h\ 22^m$ to $13^h\ 12^m$ on August 10. Of these 17 were *Perseids* with an apparently duple radiant at 38°+57° and 43°+54°·5. On August 13, from $13^h\ 30^m$ to $15^h\ 0^m$, the same observers counted 29 meteors, including 15 *Perseids*. A radiant in *Cassiopeia* at 22°+53° was also indicated from 5 meteors.

In England the weather of August was very unfavourable generally for meteoric observation. At Bridgwater the clouded skies prevented Mr. Corder from noting more than 8 *Perseids*. In July, however, he had redetected the *Aquarids* (usually forming a very pronounced display at the close of that month) and from 15 tracks found two radiants at 335°−14° and 338°−3°. The prevailing atmospheric conditions during the *Perseid* epoch appear to have been more auspicious in the north than in the south of England, for Mr. E. R. Blakeley, at Dewsbury, obtained successful views of the shower on August 6, 9, and 10, and derived the radiant as follows :—On August 6 there were apparently two centres, 39°+51° and 40°+56° (14 meteors). On August 9, one centre, 42°+56° (15 meteors). On August 10 from $10^h\ 40^m$ to $12^h\ 10^m$ the directions conformed with a radiant at 45°+55° (24 meteors), while on the same night from $12^h\ 40^m$ to $14^h\ 0^m$ the radiation seemed different, and showed a major shower at 42°+54° (20 meteors), and a minor one at 40°+59° (8 meteors). Mr. Blakeley describes his radiants as pretty definitely marked. Mr. D. Booth, at Leeds, also noticed an apparent displacement of the radiant at different hours of the same night.

On August 10, $11^h\ 35^m$, a fine *Perseid*, nearly as bright as *Jupiter*, was recorded by Mr. T. W. Backhouse at Sunderland, and by Mr. Blakeley at Dewsbury. The pair of observations are in excellent agreement, and prove the meteor to have been unusually low in the atmosphere. When first seen it was 52 miles high over a point in the North Sea in lat. 54° 16′ N., long. 0° 55′ E., and disappeared at an elevation of 16 miles in lat. 53° 55′ N., long. 0° 10′ E.

On October 2, between 10^h and 11^h, Mr. Corder noted a good flight of meteors from near *α Piscium*. In October and November the same observer recorded many slow meteors from a point in *Lacerta* at 323°+53°. The *Taurids* were not very numerously in evidence, though twenty-five of them were seen, and there appeared to be three radiants at 55°+27°, 57°+22°, and 67°+15°.

He also registered during the last week in October, and during November, 9 *Arietids* from 47°+19°, and 12 *Cetids* from 50°+6°. The October *Orionids* and November *Leonids* escaped suitable observation in consequence of brilliant moonlight. Between November 14 and 18 Professor Herschel watched the heavens during periods amounting in the aggregate to three or four hours, but not a single shooting star could be discerned in the partially clouded and moonlit sky. Mr. Corder, however, obtained glimpses of 4 *Leonids*, and of one or two *Andromedes*, but the weather was cloudy after November 25. The full Moon on December 12 interfered with the visibility of the *Geminids*, and no regular watches were undertaken at that period. The shower, however, appears to have returned pretty conspicuously on the morning of December 13, for an observer at Montreux (Suisse) says that at about 7.30 A.M. a considerable number of shooting stars were observed in the N.E. sky, not less than twenty being counted in about 10 minutes, after which the growing daylight prevented further observation.

Fireballs.—January 25, $10^h\ 1^m$. Detonating. Fell from 89 to 16 miles, over the Irish Sea to Tewkesbury. Real length of observed path 160 miles in 9 seconds (mean of 12 estimates). At Droitwich, Worcester, and other places in the Midlands the fireball caused a vibration like an earthquake shock, and people ran out of their houses in alarm. Radiant 331°+55°, near ϵ *Cephei* (see *Monthly Notices*, March 1894, p. 337).

February 8, $0^h\ 28^m$. Splendid meteor, observed in the sunshine of mid-day. Dr. A. A. Rambaut, of the Dunsink Observatory, witnessed the descent of the meteor, and collected a number of other observations, from which he found that, at first appearance, its height was 87 miles over the Irish Sea, and that at disappearance it had fallen to an elevation of 15 or 20 miles over a point near Leeds. Mr. W. H. Wood, of Birmingham, has also computed the real path of this body, and gives it as 80 miles above the Irish Sea to 17 miles above York; a result in substantial agreement with that deduced by Dr. Rambaut. The fireball moved swiftly from a radiant in *Hercules*.

February 21, $7^h\ 18^m$. Brilliant flashing meteor seen at Bristol, Dundee, North Lincoln, &c. The observations are not sufficiently full and exact to enable a reliable path to be computed. At its disappearance, however, the meteor seems to have been 30 miles high over a point near Bolton, Lancashire. It belonged to a radiant probably near θ *Ursæ Majoris*.

April 22, $7^h\ 36^m$. Large fireball observed in the evening twilight. It descended from 80 to 17 miles above Hastings to Amiens, France. Course, 120 miles in 4 seconds; velocity, 30 miles per second. Radiant not certainly defined by the observations, but somewhere in the region of α *Persei*.

August 26, $10^h\ 20^m$. Very fine meteor, moving swiftly, and giving a flash like vivid lightning, observed at many stations in the southern part of England. When first seen it was 90 miles

above a point in the river Mersey, and, travelling rapidly southwards, it ended its visible career at 30 miles above Ruthin, Denbighshire. Its observed course extended over 66 miles, and it left a very luminous streak, which was 9 miles long at first. This streak may justly be said to have formed the most remarkable meteoric apparition of the year. Its long duration, rapid drift in the higher region of the atmosphere, and successive transformations were among the more noteworthy features it presented. At many places it appeared, at first, as a phosphorescent bar, 2° or 3° long, and lying nearly vertical amongst the stars of *Ursa Major*. Quickly becoming convoluted, it drifted to S.E., and finally condensed into an irregularly shaped mass of nebulosity. At the moment of its first projection the middle of the streak was 54 miles high over a point 7 miles N.E. of Denbigh, and when last seen, 30 minutes after, by Mr. Corder at Bridgwater, it maintained the same elevation, but was then placed over a point 6 miles W. of Wolverhampton. This horizontal movement had therefore extended to 61 miles, so that the rate per hour was 122 miles, or 176 feet per second. At 10.37 it was seen by Mr. Packer, at King's Heath, near Birmingham, clouding the star ι *Draconis*, and at that time it formed a roundish mass 2° in diameter, which is equivalent to a real diameter of nearly four miles. The meteor belonged to a radiant at 305° + 79° near κ *Cephei*, and there appears to be a well-defined shower of bright, swift meteors, often leaving streaks, from this point both in August and September.

Many other fireballs were recorded during the year, notably on May 18, August 20, September 8, 24, 26, 29, &c., but the observations were not sufficiently numerous and exact to allow the real paths to be computed satisfactorily. W. F. D.

Total Solar Eclipses.

As only a few of the reports on the total solar eclipse of 1893 April 16 have yet been published, references to the results obtained are deferred until next year.

A Permanent Eclipse Committee of Fellows of the Royal and Royal Astronomical Societies has been formed for the consideration of the observation of future eclipses, and the discussion of records of those in the past.

Solar Activity in 1894.

The principal feature of the solar activity in 1894 as compared with 1893 has been a distinct falling off in the mean daily spotted area. December 1893 had been an exceptionally active month, the mean daily area being larger than for any other month during the present cycle, except August 1893, and the number

of distinct groups and of separate spots being even disproportionately great. The decline which was witnessed in the early days of 1894 was therefore the more marked, and except for the appearance of a specially fine group towards the end of February, that decline continued until the end of March. A revival then set in, and the next four months showed very nearly as heavy a record as any similar period in 1893. From the end of July, however, a second decline has been manifest, and has continued with irregularities, to the end of the year.

There has also been a continuance of the decline in latitude already noticed in the previous year, and the southern hemisphere has maintained the predominance over the northern which had been a marked feature of 1893.

According to the figures given by Professor Tacchini, the area of the sunspots in 1894 was about 74 per cent. of that in 1893; according to M. Guillaume's results the proportion was as high as 87 per cent. Both agreed, however, that the faculæ of 1894 were only slightly inferior in extent to those of 1893, being over 90 per cent. The crest of the curve, therefore, appears to have been definitely passed, though both sun spots and faculæ still exceed considerably, both in number and area, the record for the maximum year of the previous cycle.

Solar Spectroscopy.

At the meeting of the British Association at Oxford Professor Langley gave an account of his new methods for exploring and mapping the lines in the vast region of the solar spectrum which lies beyond the reach of the photographic plate in the infra red, and which, as is well known, has been rendered accessible for detailed study by the invention of the bolometer some fourteen years ago.

By the old method of working two observers at least were necessary, one to record the deflections of the recording galvanometer, and the other to read the angle determining the position in the invisible spectrum, whence any given thermo-electric disturbance arose. This process—which has been aptly described by Professor Langley as "a groping in the dark"—has now been entirely superseded, and a new and vastly improved form of apparatus has been constructed for the purpose of *automatically* recording with a high degree of accuracy both the intensity of any radiation falling upon the delicate bolometer thread and its wave-length.

In the new design the mirror attached to the needle of the galvanometer reflects a ray of light on to a photo-sensitised film, to which a vertical movement is given by clock mechanism, so that the horizontal swings of the needle are permanently impressed in the form of a curve on the film. The same

mechanism imparts a synchronous movement of slow rotation to the large rock salt prism, which forms the dispersion piece. In this way the entire spectrum is made to slowly drift past the bolometer thread (placed parallel with the lines in the spectrum), and the extremely sensitive galvanometer, which will betray a change of temperature amounting to only one-millionth of a centigrade degree in the thread, instantly responds to every variation in the energy of the radiation absorbed by the thread, as the invisible spectrum slowly moves over it; the spot of light reflected by the mirror tracing out, meanwhile, an "energy curve" on the moving film, the ordinate to this curve being proportional to the energy absorbed, and the abscissa being a function of wave length.

By means of another automatic process these bolograph energy curves are converted into ordinary lineal spectra, and any accidental disturbances arising from variations of temperature or of transparency in the atmosphere are eliminated by taking a number of bolographs of the same part of the spectrum and combining them by a process analogous to that of composite photography. The new bolograph has in this way already disclosed to us long reaches of spectrum as crowded with absorption lines as is the visible region, and extending down to a wave length of about seven microns. The large amount of detail which the apparatus is capable of revealing may be judged from the energy curve obtained, by way of trial, with the D lines in the visible spectrum. These are well separated, and show distinctly the nickel line between them.

We are now, therefore, entering upon a new era regarding this important work—the era of interpretation. The lines having been mapped over a length of spectrum equal to something like fifteen times that of the visible region, it now remains to study the relations which these lines bear to one another and to the various absorbing media of the solar and terrestrial atmospheres.

A further development of the spectro-photographic method of studying the solar surface, has, in the hands of M. Deslandres, yielded some new and important results. The interesting revelations which followed the first application of this method by Hale in America, as well as by Deslandres at Paris, were due to the particular ray selected, with which to obtain monochromatic images—namely, the centre of the K band. In this more recent work, however, M. Deslandres has obtained images from other dark lines, as well as from bright spaces in the spectrum. He finds that when the second slit of his spectro-heliograph is adjusted on some other dark line, or a little to one side of the centre of the K band, so as to avoid the bright reversals in the centre, but still keeping within the broad shade of that line, an image is obtained in which the faculæ are shown as clearly in the centre of the disc as near the limb; but they are less bright and less extensive than when the centre of K is used, and appear to correspond more closely with the faculæ as ordinarily seen, for the spots and penumbræ, so frequently veiled by the calcium radiation, are

well defined in these images, which are really images of the "reversing layer" between the chromosphere and photosphere.

It appears also that the smoke-like matter causing the general absorption near the limb must be situated below this layer, since these images are unaffected by it.

Monochromatic photographs obtained with the second slit adjusted on a bright space in the spectrum give images practically the same as by direct photography.

A detailed study of the double reversals of the H and K lines by the same investigator has revealed a curious want of symmetry between the bright and dark components of these lines in the general light of the sun. Thus, in 186 separate photographs of this region of the spectrum 120 clearly show a slight relative displacement between the central absorption line and the two edges of the broad and bright reversal on which the former appears to be projected. The bright edge on the side towards the red being in all these cases less distinct than the other edge, thus giving the central dark line the appearance of displacement towards the red. In spectra obtained from sections of the disc the two components of the reversal are sensibly equal in the brighter faculous region and also near the limb, but in all other parts of the disc this inequality prevails, the component on the red side being sometimes entirely absent.

In his persevering attempts to photograph the corona in full sunshine Professor Hale has again had to contend with discouraging circumstances. His latest experiments have been carried out on the summit of Etna.

The dark line K was selected by Professor Hale as the most suitable line for this work, although any other line might have served. Thus the line which has yielded such interesting results in photographing the chromosphere has again been pressed into service for the corona, but for a different reason.

Unfortunately at no time during Professor Hale's stay upon Etna were the atmospheric conditions so favourable as he had been led to expect, and the photographs he obtained show no evidence of true coronal forms. But this negative result will probably only lead to fresh efforts on his part to solve this interesting problem. J. E.

The Effective Temperature of the Sun.

Hitherto the chief investigators in this line have been Chatelier and Rosetti. The former deduced the effective temperature of the sun by measuring the photometric intensity of the red light from solid bodies heated to different known temperatures, and obtaining an empirical law which held approximately between 700° and 1800° C. This method is to a great extent vitiated by the fact that the absorption by red glass probably decreases as the radiation increases, and that in calculating the

whole energy it is not well to experiment solely with a group of wave lengths. Rosetti found a law of radiation which held well up to 2000° C, and measured in arbitrary units the heat radiated from an incandescent body at a known high temperature by means of a thermopile and galvanometer, and compared it with the heat coming from the sun by the same means. His empirical formula was $y=aT^2(T-\theta)-b(T-\theta)$, where y is the thermal effect of the radiation as given by the deflections on the scale of the thermopile, T is the absolute temperature of the radiating body, and θ that of the surrounding medium. This equation approximates to a law of the third power for very high temperatures. MM. Wilson and Gray, by employing a Joly's meldometer and a Boys' radio-micrometer, arrived at results which are more accurately given by a law of the fourth power. The result gives the effective temperature of the sun as 6200°C. ; or, utilising the researches of MM. Wilson and Rambaut on the absorption of heat by the sun's own atmosphere, approximately 8700°C. Later experiments by MM. Wilson and Gray point to the fact that the same law does not hold for blacked and bare platinum, and this will probably influence the determination of the sun's temperature by a few hundred degrees. A. S. D. R.

The Transit of Mercury.

The transit on November 10 was well observed in America, and a few observations were also secured elsewhere, even in the British Isles, though ingress occurred very shortly before sunset. The observers with great unanimity failed to see any ring of light round the planet, white spot on the disc, or satellite, and almost the only noteworthy remark is made by Professor Young, who has on this and three previous occasions noticed a peculiar "hardening" of the Sun's limb just before external contact, which "may be due to the planet's obscuration of the brightest part of the chromosphere close to the disc of the Sun, or to some diffraction effect at the limb of the planet."

The German Heliometer Observations of the Transits of Venus, 1874 and 1882.

Dr. Auwers has published volume v. of the series devoted to these observations. In previous volumes the observations themselves have been given ; in this the final discussion is made. The first fourteen chapters (459 pages quarto) deal with the determination of the instrumental constants, division errors, screw errors, temperature corrections, zero of focus, scale value from stars, &c. The main results of chapters xv. and xvii., which deal with the measures of diameter of the Sun and *Venus*, were published some time ago, and were noticed in the Council

Report for 1892 (*Monthly Notices*, lii. p. 279). Chapter xii. deals with the Meridian places found specially at a large number of observatories, and places in existing catalogues, of a number of stars measured by the heliometers for scale value; and the comparison of material collected from so many sources, conducted with Dr. Auwers's well-known skill, is of great value, independently of this particular research.

The discussion of the actual observations of the transits of *Venus* is contained in chapter xvi. (113 pages), and the final parallax deduced from the two transits is $8''{\cdot}896 \pm 0''{\cdot}0216$.

The Recent Opposition of Mars.

Although the greatest apparent diameter of *Mars* was less in 1894 than in 1892, being only $21''{\cdot}7$, as compared with $24''{\cdot}8$, yet the planet was much more favourably placed for observers stationed in our northern hemisphere, it having considerable north declination. So that, judging from the accounts already published, it is probable that the results obtained will equal, if not surpass, those of any preceding opposition in importance. Some of the chief points concerning the work of the past opposition may be shortly enumerated as follows:

1. The complete disappearance of the south polar spot as a visible object.

2. Numerous observations of irregularities at the terminator of the planet when it was gibbous, consisting of (*a*) small bright projections, usually in connection with a bright region just within the terminator. (*b*) Flattenings or slight hollowings of the curve of the terminator, generally at those parts where the darker regions were passing out of sight.

3. A very general confirmation of the canal system of Schiaparelli.

4. The duplication, or gemination, of a number of the canals, even at about the time of the summer solstice of the southern hemisphere.

5. Further extension of the work of Schiaparelli by the detection, chiefly at Mr. Lowell's observatory, of many additional canals and other delicate details, and of a number of minute dark spots or lakes, the latter often being curiously situated at the points where two or more canals meet or cross each other.

6. One of the most important results of the past season is certainly that relating to the presence of cloud. During recent years the opinion seems to have been gaining ground that the atmosphere of *Mars* is almost free from clouds, and that even when visible they are not of any great extent or density. But during the latter half of October last nearly the whole of the Maraldi Sea, and the extensive continental area extending north of it up to about 20° north latitude, were densely obscured by

cloud, the region affected having an area of at least 6,000,000 square miles, considerably greater than that of the whole of Europe.

7. Additional evidence in favour of actual change. For instance, the disappearance of a considerable part of the bright region named Aurea Chersonesus has been independently noted by several observers, the continental outline here being much changed from what it was in 1877, according to the maps of Mr. Green and Professor Schiaparelli.

8. Professor Campbell undertook some observations of the spectrum at the Lick Observatory, but did not succeed in confirming the earlier observations of Huggins, Rutherfurd, Vogel, and others in finding evidence of absorption due to an atmosphere.

A. S.-W.

Jupiter.

The fifth satellite remains so far the property of the discoverer that the only measures of it published during the year have been those by him. He has, however, kept a careful watch upon it, and the collected observations published in No. 325 of the *Astronomical Journal* afford material for a good determination of the orbit. The periodic time deduced is $11^h\ 57^m\ 22^s{\cdot}618 \pm 0^s{\cdot}013$; and is thus satisfactorily confirmed by the observations of Dr. Herman Struve at Pulkowa, in 1893 October (*Ast. Nach.* No. 3200), who deduced a period of $11^h\ 57^m\ 22^s{\cdot}58$ from an observed East elongation, compared with Marth's Ephemeris. Dr. Struve could recognise the satellite up to 5″ from the limb, but Professor Barnard has not recorded *measures* within 11″ of the limb. In the exhaustive paper above referred to, Professor Barnard deduces a mean distance from East elongation only during 1893, of $47''{\cdot}785 \pm 0''{\cdot}044$, at the geocentric distance 5·20 of *Jupiter*. No observations could be obtained at West elongation during 1893, but seven series were obtained in 1892, giving a mean distance $47''{\cdot}712 \pm 0''{\cdot}176$, as compared with $48''{\cdot}104 \pm 0''{\cdot}061$ from fourteen East elongations in 1892. Professor Barnard concludes that the orbit is really eccentric; and M. Tisserand has shown that the major axis must make a complete revolution in about five months. In *Ast. Nach.* No. 3267, Professor Barnard gives eight observations at West elongation on 1894 October 8, which are "the only observations he has been able to secure, though the satellite has been seen at another time; at these measures it was extremely faint." The discoverer proposes to retain the name Satellite V, remarking that if the order of discovery instead of that of distance from *Jupiter* be regarded as the criterion, the numbers I., II., III., IV., V., are probably consistent. In measuring the satellite he has incidentally measured the diameters of *Jupiter*, and finds for the

Equatorial diameter	$38''{\cdot}522$	(at Δ 5·20)
Polar diameter	$36''{\cdot}112$	„

which are about 1″ greater than heliometer measures. This systematic difference he attributes to the faulty nature of the images formed by half an object-glass in the heliometer.

Professor Newcomb has discussed* the orbit of Polyhymnia (33) and the mass of *Jupiter*, and finds for the reciprocal the mass 1047·34, which agrees well with the weighted mean (1047·35 ± 0·065) of all existing determinations.

At the end of 1893 Professor Barnard found the first satellite of *Jupiter* to have dusky poles and a bright equatorial belt,† thus confirming and explaining a previous observation in 1890, when the satellite was seen elongated. This discovery, indeed, seems to be a satisfactory explanation of several previous and mutually contradictory observations. The satellite has been announced as *ellipsoidal*, or as *double*. It is easy to see how an imperfect appreciation of the facts as now announced by Professor Barnard might lead to these interpretations of what was seen.

The Satellite of Neptune.

Dr. Hermann Struve's observations and their discussion form the subject of a memoir in Volume xlii. of the *Memoirs of the Imperial Academy of Sciences*, St. Petersburg. The observations extend over the period 1886-1893, and were made in such a manner as to exclude as far as possible systematic errors of personality and methods of observation. Thus, in measuring the position angles, he resorted to three different methods: (1) by the use of a single bright wire in a dark field; (2) a dark wire in a bright field; (3) two close parallel wires; further, he always so arranged that the line joining the planet and satellite should be either parallel or at right angles to the line joining his two eyes. The use of a single wire proved the more accurate. To make the mean times of observation in angle and distance coincident, the angles were observed in two sets, the distances being intermediate. These methods in connection with observations of twenty double stars made for the purpose, form groundwork for a thorough investigation of systematic errors. The distances were also examined thoroughly. The powers used were 515, 630, and 900.

For discussion of the observations they were divided into four groups, giving eight groups of equations (the polar formulas of Marth) and corrections to the assumed elements deduced from each series independently, the accordance of the results being eminently satisfactory. For instance, the values of the mean distance of the satellite are—

* *Ast. Nach.* No. 3249. † *Monthly Notices*, liv. p. 134.

1887·62	$a = 16''\cdot285 \pm 0''\cdot028$
1889·02	$16\cdot272 \pm \cdot019$
1890·61	$16\cdot253 \pm \cdot021$
1892·60	$16\cdot203 \pm \cdot032$

In deducing the mean motion of the satellite in its orbit, and also the motion of the plane of the orbit, Dr. Struve has used observations by Lassell, Bond, and O. Struve. The motion of the node which was first pointed out by Mr. Marth in vol. xlvi. of the *Monthly Notices* is confirmed, and Dr. Struve finds that the old and new determinations can be represented by—

$$N = 185^\circ\cdot15 + 0^\circ\cdot148\,(t-1890)\ .$$
$$I = 119\cdot35 - 0\cdot165\,(t-1890)$$

where N is node on equator and I the inclination. This motion, M. Tisserand points out, could well be accounted for by supposing a polar compression for the planet of $\frac{1}{100}$.

The elements of the orbit are—

Longitude of Satellite reckoned from the node... ...	$234^\circ\cdot42$
Mean daily motion	61·25748
Node (referred to equator)	$185\cdot15 + 0^\circ\cdot148\,(t-1890)$
Inclination (referred to equator) ...	$119\cdot35 - 0\cdot165\,(t-1890)$
Semi-axis major (at distance whose log is 1·47814)	$16''\cdot271 \pm 0''\cdot012$
Eccentricity	less than 0·01

The orbit is thus very nearly circular.

As incidental to the chief work, Dr. Struve finds—

(1) Mass of Neptune $\dfrac{1}{19396 \pm 43}$

(2) Diameter of Neptune—yellow field $2''\cdot120$

Bright red $2\cdot197$

Dark red $2\cdot273$

Professor Barnard has published (*Astronomical Journal*, No. 314) his observations of the satellite with the Lick telescope during the opposition of 1893-4.

T. L.

Double Stars.

The Society showed its appreciation of this branch of astronomy by presenting, in February 1894, its Gold Medal to Mr. S. W. Burnham for his discoveries, micrometric measures, and general work in connection with it. Since then Volume II. of

the Lick Observatory Publications has been issued, wherein is collected a great proportion of Mr. Burnham's recent work. It is a large and well-arranged volume and, from the following selected contents, is readily seen to be essential to double-star workers :

(*a*) Frontispiece showing the micrometer used with the 36-inch refractor.

(*b*) Measures of planetary nebulæ.

(*c*) Burnham's 14th, 15th, 16th, 17th, 18th, 19th catalogues of new double stars.

(*d*) Micrometer measures of known doubles.

(*e*) Work on star orbits.

Another publication which is welcome, both for its contents and its speedy issue, is Professor S. Glasenapp's "Observations Astronomiques faites à Abastouman," from 1892 August to 1893 May. These observations are in continuation of those made at Hoursouf. This is the second occasion on which Professor Glasenapp has journeyed southwards to secure the much-needed observations of southern doubles. There are 1220 measures of 610 pairs. The volume also contains such incidental work as occultations, lunar eclipse 1892 November 4, places of Comet Holmes, estimations of the variable stars *ν Arietis*, *β Lyræ*, *μ Aquilæ*, *Algol*, &c.

The only other collection of measures is that of 117 pairs made at the Royal Observatory, Greenwich, with the $12\frac{3}{4}$-inch Merz refractor, and published in the *Monthly Notices* 1894 March.

Amongst the works on double stars are Professor A. Hall's "Résumé of Different Methods of Computing Double-star Orbits" in the *Astronomical Journal* 1894 August 16 ; Professor W. Schur's "Re-determination of the Orbit and Parallax of 70 *Ophiuchi* (parallax $0''{\cdot}286 \pm ''{\cdot}031$)," "A Method of Computing a Double-star Orbit from Spectroscopic Observations of Motion in the Line of Sight," by Lehmann Filhés, in the *Astronomische Nachrichten*, 2242. Then Mr. Burnham's paper in *M.N.* 1891 April has called forth the pamphlet "Ueber den Vierfachen Stern *ζ Cancri*," in which Professor Seeliger* collects all the recent measures of this system, and shows that the undulatory motion of the distant companion C is still in evidence, and contends that no hypothesis of systematic errors due to personal equation can account for the recurrence of four revolutions (18-year period). At Georgetown College a year was spent in experimenting with a photochronograph attached to a 12-inch refractor, the object being to obtain a number of photographic images of a pair on a plate and also to derive at once a scale value. Fifteen pairs were thus photographed. These were wide pairs, and the labour involved seems scarcely to be repaid by the result.

* A translation of this will be found in *Astronom yand Astro-Physics*, 1894 December.

The orbits computed during the year are—

Star.	Period (in Years).	Computer.	Where Published
0Σ 82	90·54	J. E. Gore	*M.N.* 1894 June.
0Σ 224	96·13	J. E. Gore	*Astronomy and Astro-Physics*, 1894 Aug.
β 101	23·33	S. Glasenapp	*M.N.* 1894 March.
β 416	27·66	S. Glasenapp	Roy. Soc. N.S. Wales, 1894 June 6.
70 Ophiuchi	88·40	W. Schur	A.N. 3220–21.
η Cassiopeiæ	208·1	T. Lewis	*M.N.* 1894 November.
Sirius	50·99	C. P. Howard	*Astronomy and Astro-Physics*, 1894 June.
Sirius	51·97	S. W. Burnham	Vol. II. Lick Publications.
κ Pegasi	11·37	S. W. Burnham	„ „ „
τ Cygni	36·5	S. W. Burnham	„ „ „

T. L.

Nova Normæ.

A very interesting light was thrown upon the enigma offered by *Nova Aurigæ* by the discovery on one of the plates taken in the course of the Southern Spectroscopic Survey of Professor E. C. Pickering, of a new star bearing a striking resemblance in its spectrum characteristics to the earlier spectrum shown by *Nova Aurigæ*. The plate on which this new stellar spectrum was first seen was taken at Arequipa on 1893 July 10, and the spectrum detected by Mrs. Fleming during her examination of the plate at Harvard College on 1893 October 26. The star had been of about the 7th magnitude on July 10, and plates taken of the same region a few weeks earlier show that it could not have been as bright as the 14th magnitude on May 27, nor as the 10th on June 21. It must therefore have attained its brightness pretty rapidly. It had diminished greatly in brightness before direct visual examination could be begun, and it was only of the 10th magnitude when Professor Campbell examined its spectrum in February and March 1894. Professor Campbell's observations led him to conclude that just as its first spectrum resembled that of the first spectrum of *Nova Aurigæ*, the lines of the hydrogen series being seen double, a bright line and a dark side by side, so now, as in the case of *Nova Cygni*, its spectrum had become distinctly nebular. The importance of this is the probability it affords that both *Nova Aurigæ* and *Nova Cygni* are typical "temporary" stars even in their most characteristic details of spectrum. The place of the star for 1900 is R.A. $15^h\ 22^m\ 12^s$, Decl. 50° 13′·8 S.

Lockyer's Photographic Spectra of some of the Brighter Stars.

An important memoir on the above subject was laid before the Royal Society by Professor J. Norman Lockyer in 1892 November, and published about a year ago. The work to which it related included the taking of 443 photographs of 171 of the brighter stars. The method adopted was in the main that of the object-glass prism, the aperture usually employed being no more than 6 inches. With a prism of 45° exquisite photographs were obtained, giving spectra two inches in length from F to K, which bore a high degree of enlargement very satisfactorily.

The discussion of the photographs leads to their classification in four orders: (1) Spectra with no marked continuous absorption in the ultra-violet or violet; (2) Spectra where the absorption is marked in the ultra-violet, and extends to K; (3) Spectra where it extends to G; and, (4), four other stars, γ *Cassiopeiæ*, β *Lyræ*, P *Cygni*, and *Nova Aurigæ*. The classification is further extended to subdivisions of these orders, characterised by differences in the appearance of the principal lines, and tables are given of the wave-lengths of the strongest lines observed. The deductions Professor Lockyer draws from these photographs are in support of his Meteoritic hypothesis, and especially of his contention that there is evidence of the existence of stars of increasing temperature, as well as of decreasing. A number of reproductions of the very beautiful photographs obtained in the course of the work accompanies the paper.

The Spectra of β Lyræ and δ Cephei.

The many recent investigations of the spectrum of β *Lyræ* may be regarded as supplementary to those on *Nova Aurigæ*, the analogy between the two objects being so close that legitimate conclusions regarding one might pretty safely be extended to the other. The most important of these researches was conducted at Potsdam. It was based upon 144 spectrograms obtained by Dr. Wilsing with the International photographic telescope. The plates employed being sensitive up to λ 380, showed, for the first time, the ultra-violet part of the spectrum, which included all the more refrangible hydrogen lines, dark and bright. The solar prominence line, K, was also brilliant with a dark duplicate. The components of these and other coupled lines shifted their relative positions coincidently with the star's light-change, yet with evident outstanding disturbances, possibly comprised in a period extending over some years. Dr. Vogel's elaborate discussion of the subject was presented to the Berlin Academy of Sciences on 1894 February 8.

The Potsdam photographic results are in most satisfactory agreement with Professor Keeler's visual observations made with

the great Lick refractor in 1889, but only published in *Astronomy and Astro-Physics* for 1893 April. They related chiefly to the D_3 line. They proved besides that the variability of β *Lyræ* depends upon the fading and brightening of its continuous spectrum.

M. Bélopolsky's investigation appeared in the *Memorie degli Spettroscopisti Italiani*, for 1893 June, *t.* xxii. It is distinguished by some special features; first, the plates used being orthochromatic, the portion of the spectrum examined stretched from D to Hγ. Next, the twenty-five plates discussed were exposed with the Pulkowa 30-inch refractor. Finally, and above all, a comparison-spectrum of hydrogen, iron, or sodium, was photographed simultaneously with the star's spectrum. Absolute measurements from the fiducial lines thus afforded appeared to assign nearly the whole of the motion-displacements to the bright lines, the shiftings of which to and fro are performed as nearly as may be synchronously with the general light-change—that is, in a period of 12·9 days. The phases of the hydrogen F are noted by Dr. Vogel to be in complete accordance with those of Hζ, the ultra-violet line in which they are most characteristically marked.

Father Sidgreaves, in a paper inserted in the *Monthly Notices* for 1893 December, derived confirmatory results from forty-five spectrograms taken with the old eight-inch refractor of the Stonyhurst observatory. It appeared to him that the bright lines are at their maximum strength during the first three days after the principal minimum.

Prof. Norman Lockyer, on the contrary, regarded them as brightest soon after the secondary minimum. The materials for his research were furnished by forty-five spectrograms of β *Lyræ* taken at South Kensington with a six-inch object-glass prism fitted to a telescope of the same size; and a summary of its results, having been first communicated to the Royal Society, was published in *Astronomy and Astro-Physics* for 1894 August. The photographs showed: (*a*) periodical changes in the relative intensities of the lines; (*b*) periodical doublings of some of the dark lines; (*c*) periodical changes in the positions of the bright lines with respect to the dark ones. He inferred the presence of two bodies giving dark-line spectra, the greatest relative velocity of which in the line of sight is about 156 miles a second; and, further, the strong resemblance of one of these to *Rigel*, and of the other to *Bellatrix*. Shifting bright lines are superposed upon the double absorption spectrum; but all spectral variations bear a constant relation to the general period of the star.

Prof. Lockyer, as well as M. Bélopolsky and Father Sidgreaves, account for the two-fold obscuration of β *Lyræ* by partial eclipses occurring when the two bodies believed to compose it are situated in the line of sight from the Earth. But, according to Dr. Vogel and Professor Keeler, an eclipse-hypothesis is negatived by the fact that at the epoch of principal minimum, the coupled lines

are at their maximum of separation. In other words, the stars, instead of being in conjunction, are at elongation. Thus, the problem presented by this star remains for the present unsolved. Its interest has, if possible, been heightened by M. Bélopolsky's announcement (*Astr. Nach.* No. 3257) that δ *Cephei*, too, is a spectroscopic binary, completing its revolutions in the identical period of its light-phases. His results, however, are to be regarded as only provisional. All short-period variables may, perhaps, before long come to be regarded as multiple systems.

A. M. C.

Star Catalogues.

On his return from the Cape of Good Hope and appointment to the Directorship of the Radcliffe Observatory, Oxford, Mr. Stone determined to carry into the northern hemisphere the general survey of the stars which he had completed for the southern hemisphere in his *Cape Catalogue*, 1880. For fourteen years (1880 January 1 to 1893 December 31) the transit-circle of the Radcliffe Observatory has accordingly been devoted to the observation of stars to about the seventh magnitude, distributed over the northern hemisphere, and the result is a catalogue of 6424 stars between the North Pole and 115° south declination, some being included which are a little further south. There are roughly 29000 square degrees in the portion of the heavens surveyed, giving an average of rather less than one star to a photographic plate (four square degrees) as planned by the International Conference. Such a comparison reminds us of the magnitude of the astrographic scheme.

The epoch of the catalogue is 1890. Proper motions have been deduced in all cases, where comparison with previous catalogues shows them to be large, and the reference numbers to six such catalogues, commencing with Bradley (1755) and ending with Greenwich (1880) are given. In a brief introduction, Mr. Stone points out that the systematic errors of the catalogue cannot be large.

Observations of the Sun have been made during the years 1884–91, and discussed separately year by year, as well as by grouping the whole series ; and an epoch correction of $+0^{s}\cdot014$ adopted. The flexure, as determined by the horizontal collimators, was very steady, the coefficient being confined within the limits $1''\cdot25$ and $1''\cdot10$. A discussion of circumpolar observations affords evidence for a slight diminution of Bessel's mean refractions, which has not, however, been applied. The correction to adopted colatitude was found insensible.

The work "owes its existence" not only to the untiring energy of Mr. Stone and the staff of the Radcliffe Observatory, but "to the liberality of the Radcliffe Trustees."

Vol. xvii. of the *Results of the Argentine National Observa-*

tory, and the twelve maps referred to in the last Report, have been published during the year.

M. Nyrén has published a Catalogue of Mean Declinations of 450 fundamental stars, observed with the Pulkowa Vertical Circle, during the years 1882–1891. The epoch of the Catalogue is 1885. A comparison with the similar Catalogue for 1865 is given in a brief introduction.

The *Cape Catalogue* (1885–90) has also been published, but has not yet been received by the Society.

A five-year catalogue of 258 fundamental stars for 1890 has been published by the Astronomer Royal, and the places used in the *National Almanac* for 1896.

A volume of the Revision of the *Durchmusterung* has been published by the Bonn Observatory ($+40°$ to $+50°$, 18457 stars).

Spectroscopic Observations of Nebulæ.

An important paper by Professor Campbell on the spectra of the *Orion* and other nebulæ, appeared in *Astronomy and Astro-Physics* for May last. Professor Campbell gives tables of bright lines photographed in the *Orion* nebula, of dark lines photographed in *Orion* stars, and of the comparison of bright nebular and dark star lines. He comes to the conclusion that "nearly all the dark lines in the faint stars are matched by bright lines in the nebula, but there is no reason known at present for supposing that the prominent nebular lines $\lambda 5007$, $\lambda 4959$, $\lambda 4346$, $\lambda 3869$, $\lambda 3727$ are matched by dark stellar lines. They appear to remain characteristic of the nebular spectrum. The fact that some or all of these positions are not occupied by dark lines renders it doubtful whether any of the lines are due to absorption by the nebula proper, and we cannot say that these stars are beyond the nebula or are physically connected with it. We may say that they are closely related to the nebula in chemical constitution, and relatively closely in physical constitution."

In the continuation of this paper Professor Campbell gives the results of visual and photographic observations of six planetary nebulæ, combining the whole result in a table which gives in parallel columns the bright lines of the *Orion* nebula, and of the planetary ones. "The prevalence," he says, "of the same lines in these nebulæ is very noticeable, and it would be found to be much more general if the nebulæ were more nearly of the same density, so that equivalent exposures could be made." There are a few points of correspondence between the nebular spectrum and that of the Wolf-Rayet stars, but there are so many points where correspondence is lacking that we cannot say the two types are closely related.

Professor Keeler's spectroscopic observations of nebulæ made at the Lick Observatory have appeared in full in the last volume

of the *Publications* of that observatory, The following are the principal conclusions at which he arrives :

1. The normal position of the chief nebular line is λ5007 ±0·03 on Rowland's scale.

2. The normal position of the second line is λ4959·02±0·04. This line is 1·39±0·04 tenth-metres less refrangible than the centre of the double line of iron at λ4957·63.

3. The first and second nebular lines are not represented by absorption lines in the solar spectrum, as shown in Rowland's map.

4. The relative brightness of these two lines is, within the limits of error of estimation, the same for all nebulæ. Hence there is reason for thinking that they are due to the same unknown substance, perhaps an element of somewhat the same nature as the so-called helium.

5. The spectrum of the bright line nebulæ indicates either a high temperature of the gases emitting the light, or a state of strong electrical excitement, and shows that the temperature and pressure are greatly increased at the nucleus.

6. The distance between the great nebula of *Orion* and the Sun is increasing at the rate of 11±0·8 miles per second.

7. No relative motion of different parts of the *Orion* nebula could be detected.

8. The nebulæ are moving in space with velocities of the same order as those of the stars. Of the nebulæ observed, G.C. 4373 has the greatest motion of approach, namely, 40·2 miles per second ; and N.G.C. 6790 the greatest motion of recession, 30·1 miles per second.

10. The visible spectrum of the nucleus of a planetary nebula has in many cases a resemblance to that of stars of the Wolf-Rayet class, though the two principal nebular lines are absent from the latter.

In a paper on the continuance of his observations on the spectra of nebulæ made at the Allegheny Observatory, Professor Keeler gives a table of the wave-lengths of the bright lines measured on photographs of the spectrum of the *Orion* nebula, and a second table of the positions of the dark lines in the spectra of the trapezium stars, also of the lines in the lower spectrum of *Rigel*. He discusses at length a comparison of the bright nebular lines with the dark lines in the spectra of the *Orion* stars, and concludes that these demonstrate the intimacy of the relation which exists between the *Orion* nebula and the neighbouring stars—indeed, "the spectrum of *Rigel* may almost be regarded as the nebular spectrum reversed." According to Professor Keeler, while the relation to the nebula of the trapezium stars is more certain than ever, they can no longer be regarded as necessarily situated in the nebula. The broadness of the hydrogen absorption lines precludes the supposition that the absorption is due to the nebula itself, and the stars may therefore, within indefinite limits, be placed anywhere in the line of sight.

The Potsdam Photometry.

The most recent and most complete of modern researches on the visual magnitude of the stars has lately been brought to the conclusion of its first stage. Doctors Müller and Kempf, of Potsdam, have published* their observations of the brightness of all stars in the zones 0° to +20° declination whose magnitude is not recorded as fainter than 7·5 in Argelander's Durchmusterung, 3522 stars in all. Within a few years they hope to complete this survey to the North Pole. The photometer chosen is that of Zöllner, three different instruments adapted to stars of different brightness being used. A list of 144 fundamental stars well distributed throughout the sky was first prepared and the determinations of their brightness carried to an extreme degree of accuracy, discussions being made of the influence of colour in the star and of personality in the observer. With these as reference points, the general mass of the stars was examined in short zones of twelve stars each, a pair of standard stars being measured at the beginning, in the middle, and at the end of each zone; the magnitude of every star was determined once by each observer, and the accordances are so close as to justify the observers in regarding their work as a considerable advance not only in scope but in accuracy on anything that has been done before. The final catalogue of 3522 stars gives a reference to the B.D., the R.A. and declination for 1900, the B.D. mag., the separate determinations by the two observers, with references to the zones where their original observations are to be found, a compendious note on the colour of the star, and other remarks of interest. The arrangement of the work leaves, in fact, nothing to be desired in the way of completeness and facility of reference Finally a comparison is made between the present work and the Oxford and Harvard Photometries, cases of large discordance being carefully noted.

The Astrographic Chart.

As no *Bulletin du Comité Permanent* has been published during the year, all our information on the progress of the photographic mapping of the heavens is derived from a few scattered notices and reports of observatories. Seven of the associated observatories have already taken more than half the number of catalogue plates assigned to them. There is every reason to hope that all the photographs for the catalogue—with the possible exception of those allotted to the South American observatories—will be completed in two or three years time. The number of chart (long exposure) plates taken is, however, much smaller, and at the present rate of progress, this part of the work

* *Potsdam Observatory Publications*, vol. ix.

will not be completed by 1900. No reproductions of the plates have yet been published.

In the work of measuring the catalogue plates the French observatories have taken the lead. At the beginning of the year seventy-two plates had been measured at Paris and thirty-eight at Algiers, and the work is in full progress. Several other observatories have begun this laborious task, but there are at present no means for assigning even an approximate period for its completion. During the year a memoir has been published by M. Anders Donner, on the reduction of the measures of the Helsingfors plates ; and two notes have appeared in the *Monthly Notices* in which the simple linear method of reduction given by Professor Turner in 1893 November, is practically applied.

We report with regret the deaths of Father Denza and M. Maturana, directors respectively of the observatories of Rome and Santiago, both of which are co-operating in the work of photographing the heavens. F. W. D.

Astronomical Photography.

The rapidly increasing importance of the photographic method would seem to make it especially desirable to summarise the history of the year. There is, however, a peculiar difficulty in so doing. The questions of the systematic reproduction of photographs, and of the form in which measures, made on plates which it is not intended to reproduce, shall be given, are not yet settled ; and anything like a complete knowledge of what has been done during the year is thus almost impossible. In future Reports of the Council it is hoped to deal more fully with such a summary. For the present it may be mentioned that in volume iii. of the *Lick Observatory Publications*, there are some beautiful enlargements of lunar photographs taken with the 36-inch refractor, stopped down to 8 inches ; that Dr. L. Weinek, who made the enlargements, has also published some equally fine enlargements of lunar negatives taken by MM. Lœwy and Puiseux at Paris ; that Dr. Roberts has published his photographs of star clusters and nebulæ, which are referred to elsewhere ; and that Professor Barnard of the Lick Observatory has sent to this Society sixty positives of stars and comets, the publication of which is under consideration by the Society.

The Council of the Society have further determined to consider fully the question of reproduction of photographs, with the view of acting as a centre for distribution of permanent copies at approximately cost price. The details are under consideration, and it may take some time to arrive at a final plan of procedure ; but if the Council have rightly estimated the advantages of such a scheme, it cannot be made generally known too early. Information and advice from others will be cordially welcomed, and can-

not fail to be of the greatest assistance in organizing the systematic reproduction of photographs.

Variation of Latitude.

Several papers of considerable importance in connection with the variation of latitude have been published during the year. Mr. Chandler has reduced and discussed the observations made by Pond at Greenwich in the years 1825 to 1835 with two mural circles. "This beautiful series of observations may be regarded as one of the most remarkable in modern astronomy. Hitherto, however, astronomy has not reaped its benefits from the fact of Pond's inadequate reduction of them." Pond's device was to observe a star directly with one instrument and by reflection with the other at the same culmination, reversing the arrangement on another night. Mr. Chandler selects 7176 combinations of thirty-six stars, and after carefully investigating the systematic errors of refraction, possible temperature effect on runs, &c., uses this valuable material for determining the oscillation of latitude, which satisfactorily corresponds with his tentative hypothesis. The continuation of the series from 1836 to 1851 under Airy's directorship, though not so homogeneous, is also discussed, yielding 4353 observations. This is the last of the individual series of observations successively examined by Mr. Chandler, and he has proceeded to make a definitive discussion of the whole. The results may be briefly stated as follows:

There are two terms of latitude variation, whose periods are respectively one year and 428·6 days, and whose mean coefficients are equal, each being 0″·135; but both the epochs and coefficients of these terms are affected by a slow oscillation in a period of about sixty or seventy years, the amplitude of the oscillation for the 428-day term being about 0″·1, and of the annual term about 0″·05; it is suggested that the pole rotates, not in a circle, but in an ellipse with revolving apses; this suggestion receives support from the discussion of the observations between 1889 and 1894, during which years special observations have been made under the direction of the International Geodetic Association. A brief account of the special series at Kasan and Karlsruhe and at Strassburg and Bethlehem was given by Dr. Förster at the meeting of the British Association at Oxford, and the full report by Professor Albrecht has been published. Some valuable observations were also made at San Francisco by Professor Geo. Davidson. Mr. Chandler's papers are printed, as before, in the *Astronomical Journal.*

New Observatories.

Recently several new Observatories have been established and changes made in others. Mr. Percival Lowell, a citizen of Boston,

has built an observatory for himself, longitude 112° W., latitude 35° N. in the territory of Arizona, near the town of Flagstaff, at an elevation of 7300 feet above the sea. This site is said to be higher than that of any large observatory in the Northern hemisphere. The equipment consists mainly of two telescopes with object glasses, respectively of 18 inches and 12 inches aperture, mounted as a twin instrument on an equatorial mounting. It is purposed to use the larger of these for spectroscopic and general eye observations, and the smaller for photography. The scheme of work laid down by Mr. Lowell for the observatory is chiefly the examination of planetary detail, and he and his assistants, Professor W. H. Pickering and Mr. Douglass, have published extensive reports of observations of *Mars* in recent numbers of *Astronomy* and *Astro Physics*. Another of the institutions referred to above is the Manora Observatory, Lussinpiccolo, Austro-Hungary, under the direction of Herr Leo Brenner, who has for his use a 7-inch refractor by Reinfelder and Hertel, with which he observes the details of lunar and planetary surfaces.

The Dudley Observatory, Albany, U.S.A., which was established in 1857, under the direction of Dr. B. A. Gould, has recently been transfered to a new site. Several reasons, among which was the proximity of a railroad, conspired to make the transference advisable, and a liberal donation by Miss Catherine Bruce, together with the proceeds of a public subscription, provided funds for building a new observatory on a site given by the City of Albany in exchange for the former grounds and buildings. The new site is in the western part of Albany, but its geographical coordinates are not known with great certainty. The adopted longitude of the transit circle is $4^h\ 55^m\ 6^s{\cdot}8$ W., latitude 42° 39′ 12″·7 N. The old observatory was abandoned in June 1893, at which time the new buildings were nearly ready for use. The instruments were then transferred, and were arranged ready for observation by the beginning of 1894. The transit circle is the Olcott Meridian Circle, which had been used in the old observatory since its foundation, and with which the observations for the zone-catalogue contributed by Albany to the catalogue of the *Astronomische Gesellschaft* were made. This instrument is described in the Introduction to the Albany Zone-Catalogue. A new equatorial telescope has been provided by funds supplied by the sons of the late R. H. Pruyn, formerly President of the Observatory Trustees. This telescope of 31 cm. aperture, made by the firm of Warner and Swasey, Mr. Brashear supplying the optical parts, has been actively used since 1894 March 29 for observation of position of comets and small planets.

A powerfully equipped observatory has recently been formed at Manila in the Philippine Islands, in latitude about 14° N., where there has been for some years a meteorological and seismographic observing station. The observatory is under the direction of Father Algué, and owns an equatorial having an object glass by Merz of 19·2 English inches in diameter, and provided

with a photographic correcting lens, which is to be used for photographic, spectrographic, and visual work on stars. The work immediately in hand is the making of observations for the determination of variation of latitude, in connection with similar work by Fathers Hagen and Fargis at Georgetown College Observatory. The instrument used for this at Manila is the Reflecting Zenith Telescope with two objectives, described in *Monthly Notices*, vol. liv. p. 264. No observations have yet been published from this observatory.

Dr. Lewis Swift, formerly of the Warner Observatory, Rochester, U.S.A., is now in charge of an observatory lately erected by Professor T. S. C. Lowe, Echo Mountain, Southern California, sixteen miles north-east of Los Angeles, and about 3500 feet above sea-level. The equipment of this observatory consists of the 16-inch Clark refractor and other instruments which have been used by Dr. Swift at Rochester. A noteworthy incident at this young institution has been the finding of a comet by Edward Swift, son of the director.

A note in the *Astronomische Nachrichten*, No. 3232, published in June last, announced that the Observatory at Karlsruhe was to be abandoned, and its instruments to be used in furnishing a new observatory at the University of Heidelberg, of which Professors Valentiner and Max-Wolf were to be directors respectively of the astronomical and astrophysical departments.

H. P. H.

Papers read before the Society from March 1894 to January 1895.

1894

Mar. 9. A seconds contact-maker for astronomical clocks. H. C. Russell.

Brilliant detonating fireball of 1894 January 25. W. F. Denning.

Remarks upon Mr. Stone's corrections to the measure of time since 1864. Professor S. Newcomb.

Note on the star DM + 27°·725. A. M. W. Downing.

On the proper motion of stars in the Dumbbell Nebula. A. A. Rambaut and W. E. Wilson.

Note on star corrections in N.P.D. W. E. Cooke.

On star corrections. Professor H. H. Turner.

Description of a perfectly achromatic refractor. H. D. Taylor.

Results of micrometer measures of double stars with the $12\frac{3}{4}$-inch Merz refractor at the Royal Observatory, Greenwich, during the year 1893. Communicated by the Astronomer Royal.

New orbit of 9 *Argûs*, β 101. Professor S. Glasenapp.

Apr. 13. Note on Professor Newcomb's remarks upon Mr. Stone's proposed corrections to the measure of time. E. J. Stone.

Occultation of *a Virginis* observed at Dunsink, 1894 March 22. Professor A. A. Rambaut.

Photograph of the cluster M. 46, and of the nebula H IV. 39 *Argûs*. Isaac Roberts.

Photograph of a "new" spiral nebula in *Perseus*. Isaac Roberts.

Photograph of the nebula H I. 156 *Persei*. Isaac Roberts.

The star cluster 3315. H. C. Russell.

Remarks on the best method of determining the positions of the planets by observation. David Gill.

Observations of Comet *a* 1894 (Denning), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Observations of Comet *a* 1894 (Denning), made at the Liverpool Observatory. W. E. Plummer.

1894 Ephemeris for physical observations of *Mars*, 1894.
April 13. A. Marth.

An experiment with a 12½-inch refractor, whereby the light lost through the secondary spectrum is separated out and rendered approximately measurable. H. D. Taylor.

Note on some photographs taken with a visual telescope. H. F. Newall.

On graduating wedges. Captain W. de W. Abney.

May 11. Note on the computation of the brightness of the planets, with some ephemerides for observations of the brightness of *Mercury*. A. Marth.

Note on the red spot on *Jupiter*. Joseph Gledhill.

Observations of the phenomena of *Jupiter's* satellites at Bermerside Observatory, Halifax, in the years 1892 and 1893. Joseph Gledhill.

Photograph of the nebulæ M. 78 and $H_{\odot}$ IV. 36 *Orionis*. Isaac Roberts.

Photograph of the nebula M. 74 *Piscium*. Isaac Roberts.

Two questions on Mr. Stone's proposed correction to the measure of time. Professor S. Newcomb.

The effect of personality in observations of the Sun's right ascension on the determination of the position of the ecliptic. F. W. Dyson and W. G. Thackeray.

On some possible improvements in meridian and extra-meridian observing. Professor H. H. Turner.

Note on the solar eclipse of 1598. J. L. E. Dreyer.

Note on the proper motion of the star L L 38239. J. L. E. Dreyer.

Differences of R.A. and N.P.D. of *Uranus* and 8 *Libræ* and *α Libræ* about the time of the conjunction in 1894 April, observed with the transit-circle at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Reply to Professor Newcomb's two questions on the proposed correction to the measure of time. E. J. Stone.

A new variable star of Type IV. Rev. T. E. Espin.

On the dimensions of *Saturn's* disc. Hermann Struve.

Observations of Comet *b* 1894 (Gale), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

June 8. Note on the lunar theory. Professor E. W. Brown.

The discovery of comets. W. F. Denning.

Photograph of the cluster $H_{\odot}$ VI. 37 *Argûs*. Isaac Roberts.

Photograph of the nebulæ $H_{\odot}$ V. 42 and $H_{\odot}$ I. 176, 177 *Comæ Berenicis*. Isaac Roberts.

1894 Photograph of the nebulæ M. 65, 66, and $\frac{H}{G}$ V. 8 *Leonis*.
June 8. Isaac Roberts.

Note on the variable star U *Orionis*. Lieutenant-Colonel E. E. Markwick.

Comet *b* 1894 (Gale), observed at Sydney Observatory. H. C. Russell.

Orbit elements of Comet *b* 1894 (Gale). John Tebbutt.

Note on the star B.A.C. 5255 = Brisbane 5525. A. M. W. Downing.

On two distribution maps of the nebulæ and clusters in Dr. Dreyer's Catalogue of 1888. Sidney Waters.

Motions of fireballs and shooting stars relatively to the earth. W. F. Denning.

On the semi-annual variation of meteors. G. C. Bompas.

On the orbit of OΣ 82. J. E. Gore.

Remarks on Dr. Roberts's photographs of star clusters. E. B. Knobel.

On some points connected with the integration of the differential equations of the relative motions of material systems. E. J. Stone.

Note on the distribution of the stars generally used for the determination of clock-error. E. J. Stone.

Ephemeris of the satellites of *Mars*, 1894. A. Marth.

Ephemeris for physical observations of *Jupiter*, 1894–95. A. Marth.

Some measures of photographs of the *Pleiades* at the Oxford University Observatory. Professor H. H. Turner.

On the formation of photographic star-discs. H. F. Newall.

On the R — D discordance. Professor H. H. Turner and W. G. Thackeray.

Observations of Comet Gale (*b* 1894), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Observations of Comet Gale, made at the Cambridge Observatory with the Northumberland Equatorial and square bar micrometer. Communicated by Sir R. S. Ball.

Nov. 9. Note on Comet Gale (*b* 1894). W. F. Gale.

Observations of Comet *b* 1894 (Gale), made at the Cambridge Observatory. Communicated by Sir R. S. Ball.

Observations of Comet *b* 1894 (Gale), made at the Royal Observatory, Cape of Good Hope. Communicated by Dr. Gill.

Observations of Comet *b* 1894 (Gale), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

1894 Nov. 9. Micrometrical measures of the diameters of *Ceres*, *Pallas*, and *Vesta*, made with the 36-inch refractor of the Lick Observatory. E. E. Barnard.

On the proper motions of Groombridge, 1172, W.B. (2) XII. 740–1, W.B. XII. 632. A. C. D. Crommelin.

Ephemeris for physical observations of *Jupiter*, 1894–95 (concluded). A. Marth.

Note on Professor Turner's paper on the reduction of measures of photographic plates. F. W. Dyson.

Note on stars suitable for the determination of clock-errors. A. M. W. Downing.

Data for computing the positions of the satellites of *Jupiter*, 1894–95. A. Marth.

Note on the lunar theory. Professor E. W. Brown.

On the computation of star-corrections. W. H. Finlay.

Photograph of the nebulæ ♅ I. 84 ; *h* 1442; and ♅ II. 344 *Comæ Berenicis*. Isaac Roberts.

Photograph of the nebulæ ♅ I. 143 and II. 536 *Virginis*. Isaac Roberts.

Comparison of the Pulkowa Catalogue (1885) with the Greenwich Ten-Year (1880) and Five-Year (1890) Catalogues. W. G. Thackeray.

Note on the binary star *κ Pegasi* (β989). T. Lewis.

On the orbit of *η Cassiopeiæ* (Σ 60). T. Lewis.

Note on solar observations at Stonyhurst College Observatory. Rev. W. Sidgreaves.

Note on the latitude of the Royal Observatory, Cape of Good Hope. David Gill.

Preliminary note on the position of the Liverpool Observatory. W. E. Plummer.

Observations of Comet II. 1894 (Gale), made at the Liverpool Observatory. W. E. Plummer.

On the rotation and mechanical state of the Sun. R. A. Sampson.

On the effect of atmospheric dispersion on the position of a star. Professor A. A. Rambaut.

Note on Mr. Stone's theory of the measure of time. Professor S. Newcomb.

A comparison between the results of the Radcliffe Catalogue of stars (1890) and the Greenwich Five-Year Catalogue (1890). E. J. Stone.

Dec. 14. The annular eclipse of the Sun, 1894 April 6, and the solar eclipse of 1894 Sept. 29. C. Michie Smith.

The solar eclipse of 1894 Sept. 29. Captain H. G. Thomas.

Results of micrometer-comparisons of *Uranus* and *α Libræ*. John Tebbutt.

Observations of the transit of *Mercury*, 1894 Nov. 10, made at Grahamstown, Cape of Good Hope. L. A. Eddie.

1894 Observations of the transit of *Mercury*, 1894 Nov. 10.
Dec. 14. Lieutenant Basil Taylor.

On the proper motion of three stars in the constellation *Ophiuchus*. W. T. Lynn.

On the late transit of *Mercury* (1894 Nov. 10). Rev. S. J. Johnson.

Observations of the transit of *Mercury* on 1894 Nov. 10, at Sidmouth, Devon. A. F. Lindemann.

Notes on suitable stations in Norway for viewing the total solar eclipse of 1896 Aug. 8. Colonel A. Burton-Brown.

Observation of a daylight occultation of *Antares*. John Tebbutt.

Observations of *Polaris* made at the Royal Observatory, Greenwich, in the years 1836–93. W. G. Thackeray.

A comparison of some places of stars observed at the Sydney Observatory with the places of the same stars given in the Cape Catalogue, 1880. H. P. Hollis.

A re-determination of the epoch correction and mean motion for Hansen's Lunar Tables from meridian observations of the Moon, 1750–1892. E. J. Stone.

Note on Professor Newcomb's note in the *Monthly Notices* for Nov. 1894. E. J. Stone.

Account of the measurement and comparison of a set of four astrographic plates, made at the Royal Observatory, Greenwich. W. H. M. Christie and F. W. Dyson.

Remarks on three volumes of Sun-spot drawings presented to the Society. Rev. F. Howlett.

1895
Jan. 11. Observations of the transit of *Mercury*, 1894 Nov. 10, made in New South Wales. H. C. Russell.

Preliminary note on the determination of terrestrial longitudes of photography. Captain E. H. Hills.

Mean areas and heliographic latitudes of Sun-spots in the year 1892, deduced from photographs taken at the Royal Observatory, Greenwich; at Dehra Dûn (India), and in Mauritius. Communicated by the Astronomer Royal.

Observations of Encke's comet made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Observations of occultations of stars by the Moon, and of phenomena of *Jupiter's* satellites, made at the Royal Observatory, Greenwich, in the year 1894. Communicated by the Astronomer Royal.

On the need and usefulness of co-operation in meridian observation. Professor T. H. Safford.

Index catalogue of nebulæ found in the years 1888–94,

1895 Jan. 11. with notes and corrections to the New General Catalogue. J. L. E. Dreyer.

On the measurement and reduction of the plates for the Astrographic Chart. Professor H. H. Turner.

Observations of comets Sawerthal, 1888; Davidson, 1889; Wolf, 1891; Holmes, 1892; Rordame-Quénisset, 1893; and Encke, 1894; made at the Radcliffe Observatory, Oxford. Communicated by E. J. Stone.

Estimated magnitude of *Nova Aurigæ*. Communicated by E. J. Stone.

Preliminary note on a modified (Oblique) form of Cassegrain telescope. Dr. A. A. Common.

List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

Her Majesty's Government in Australia.
Her Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The French Ministry of Public Instruction.
The Italian Government.
The Norwegian Government.
British Association for the Advancement of Science.
British Astronomical Association.
British Horological Institute.
Camera Club.
Geological Society of London.
Institution of Civil Engineers.
Meteorological Office.
Royal Photographic Society of Great Britain.
Physical Society of London.
Royal Geographical Society.
Royal Institution of Great Britain.
Royal Meteorological Society.
Royal Observatory, Greenwich.
Royal Society of London.
Royal United Service Institution.
Society of Arts.
University College, London.
Belfast Natural History and Philosophical Society.
Birmingham Philosophical Society.
Cambridge Philosophical Society.
Cardiff, Astronomical Society of Wales.
Cork, Queen's College.
Dublin, Royal Irish Academy.
Dublin, Royal Society.
Edinburgh, Royal Observatory.
Kew Observatory.
Leeds Astronomical Society.
Liverpool Observatory.
Manchester Literary and Philosophical Society.
Oxford, Delegates of the Clarendon Press.
Oxford, Radcliffe Library.
Oxford, Radcliffe Observatory.

Rugby School Natural History Society.
Stonyhurst College Observatory.
Adelaide Observatory.
Amsterdam, Royal Academy of Sciences.
Australasian Association for the Advancement of Science.
Batavia, Magnetical and Meteorological Observatory.
Belgium, Royal Observatory.
Berlin, Physical Society.
Berlin, Royal Prussian Academy of Sciences.
Berlin, Royal Observatory.
Berne University.
Bombay Branch of the Royal Asiatic Society.
Bombay Government Observatory.
Boston, American Academy of Arts and Sciences.
Brisbane, Royal Geographical Society of Australasia.
Buda-Pesth, Royal Hungarian Institute for Meteorology and Terrestrial Magnetism.
Buenos Ayres, Argentine Meteorological Office.
Calcutta, Asiatic Society of Bengal.
Cape of Good Hope, Royal Observatory.
Cape Town, South African Philosophical Society.
Charkow, University Observatory.
Christiania, Norwegian Geodetic Commission.
Copenhagen, Royal Danish Academy of Sciences.
Cordoba, Argentine National Observatory.
Cracow, Academy of Sciences.
Delft, Polytechnic School.
Geneva, Society of Arts.
Georgetown College Observatory.
Göttingen, Royal Observatory.
Göttingen, Royal Society of Sciences.
Haarlem, Teyler Museum.
Halle, Leopold-Caroline Academy of Naturalists.
Harvard College Astronomical Observatory.
Helsingfors, Geographical Society of Finland.
Helsingfors, Society of Sciences of Finland.
Hong Kong Observatory.
India, Survey Department.
Kasan, Astronomical Observatory.
Kasan, Imperial University.
Kiel, Royal Observatory.
Leiden Observatory.
Leipzig, Astronomical Society.
Leipzig, Royal Saxon Society of Sciences.
Lick Observatory.
Lund Observatory.
Madras, Government Observatory.
Madrid Observatory.
Manila, Meteorological Observatory.
Mauritius, Royal Alfred Observatory.

Melbourne Exhibition Trustees.
Melbourne Observatory.
Melbourne, Royal Society of Victoria.
Moncalieri Observatory.
Montpellier, Academy of Sciences.
Moscow, Imperial Society of Naturalists.
Munich, Royal Bavarian Academy of Sciences.
Naples, Academy of Sciences.
Naples Observatory.
Natal Observatory.
New York Mathematical Society.
O-Gyalla, Astrophysical Observatory.
O-Gyalla, Central Meteorological and Magnetical Observatory.
Ottawa, Canadian Meteorological Society.
Ottawa, Royal Society of Canada.
Paris, Academy of Sciences.
Paris, Astronomical Society of France.
Paris, Bureau of Longitude.
Paris, General Depot of Marine.
Paris, International Committee of Weights and Measures.
Paris, International Geodetic Association.
Paris, Mathematical Society of France.
Paris Observatory.
Paris, Philomathic Society of France.
Paris, Polytechnic School.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Potsdam, Astrophysical Observatory.
Prague, Imperial Observatory.
Puebla, Catholic College.
Pulkowa Observatory.
Rome, Central Meteorological Office.
Rome, Italian Spectroscopic Society.
Rome, Pontifical Academy *dei Lincei*.
Rome, Royal Academy *dei Lincei*.
Rome, Vatican Observatory.
St. Petersburg, Imperial Academy of Sciences.
San Fernando Observatory.
San Francisco, Astronomical Society of the Pacific.
St. Louis, Academy of Sciences.
Stockholm, Royal Swedish Academy of Sciences.
Sydney, Government Observatory.
Sydney, Royal Society of New South Wales.
Tacubaya Observatory, Mexico.
Tiflis, Physical Observatory,
Toronto, Astronomical and Physical Society.
Toronto, Canadian Institute.
Toronto University.
Toulouse, Academy of Sciences.

Trieste, Astronomical and Meteorological Observatory.
Turin, Royal Academy of Sciences.
Upsala, Royal Society of Sciences.
Vienna, Austrian Geodetic Commission.
Vienna, Imperial Academy of Sciences.
Vienna, Imperial Observatory.
Vienna, von Kuffner's Observatory.
Washburn Observatory of the University of Wisconsin.
Washington, National Academy of Sciences.
Washington, Office of the American Ephemeris.
Washington, Smithsonian Institution.
Washington, United States Coast and Geodetic Survey.
Washington, United States Naval Observatory.
Yale University Astronomical Observatory.
Zurich, Central Meteorological Institute of Switzerland.
Zurich, Geodetic Commission of Switzerland.
Zurich, Natural History Society.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of the "Astronomische Nachrichten."
Editors of "Astronomy and Astro-Physics."
Editors of the "Astrophysical Journal."
Editor of the "Athenæum."
Editors of the "Bulletin des Sciences Mathématiques."
Editor of the "English Mechanic."
Editor of "Himmel und Erde."
Editor of "Indian Engineering."
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ADDRESS

Delivered by the President, Captain W. de W. Abney, C.B., R.E., D.C.L., F.R.S., on presenting the Gold Medal to Dr. Isaac Roberts.

The Medal of the Royal Astronomical Society has been awarded to Dr. Isaac Roberts, F.R.S., for his photographs of star clusters and nebulæ. It is always a congenial task for the occupant of this chair to explain the reasons why the choice of the Council has fallen on any distinguished astronomer, and more especially so when it happens that it falls on one of our own Fellows. On both occasions on which I have occupied this chair the choice has so fallen. Last year my remarks were addressed to a consideration of the eye observations carried on for many long years by a single observer; this year the eye has to hold a subordinate place, giving way to the photographic plate as a recorder. The latter is a recorder in which there can be no systematic personal error as regards the relative positions of objects which cannot be discounted; and though photography in some particulars does not always speak the truth, yet for a study of the heavens its retina is capable of receiving more accurate impressions than that sensitive surface which lines the eye, and which transmits a message to the brain, more or less tainted with preconceived notions. Your retiring President is in a position to fully appreciate the magnitude of the work undertaken by Dr. Roberts. A thirty-two years' experience in every past or present photographic process has impressed deeply on his mind the remarkable strides that the science of photography has made since he first developed a wet plate. It seemed then to be amongst the improbabilities that a surface should ever be prepared which should be rendered so exquisitely sensitive to light that it could be with advantage employed by the astronomer who wished to make a register of the heavens. Most of the members of this Society who are photographers have only probably studied the "new photography," if it may so be called, which had its birth when Bennett showed that a salt of silver (the bromide) when suspended or emulsified in gelatine could have imparted to it, by long warming at a moderate temperature, a sensitiveness which was twenty to thirty times that of the same salt when

used in the ordinary wet process. The success thus achieved was not at the time fully appreciated, except by some few earnest workers, to whom the further improvement of the photographic plate naturally fell. The long heating at a gentle warmth took the place of the more brutal process of boiling the liquefied gelatine, and even heating was found to be unnecessary when strong liquid ammonia was added to it. Long were opinions divided as to the advantages of the hot over the cold preparation of the sensitive material, and I am inclined to believe that to the present day a diversity of opinion exists. But with improvements such as these a picture of a portion of the heavens, which Rutherfurd took eight minutes to obtain, can now be secured in a quarter as many seconds; and it is possible by very prolonged exposure to secure images of stars which have never been seen, though after their positions are known the eye is able to glimpse them in some of the largest telescopes.

The photographs by Common of the great nebula in *Orion* were epoch-marking in astronomical photography, and worthily was the medal bestowed on him for his classic work, and it is no disparagement of the labours of the present recipient if one traces in them the mark of what Common had shown to be possibilities. Dr. Roberts may have been said to have commenced his labours, which we are now considering, nearly ten years ago, for in 1885 April he had constructed for him by Grubb a 20-inch silver on glass reflector of nearly 100 inches focal length. As naturally to be expected when applying an instrument to a novel purpose, some defects in its mounting were found, and some short time elapsed before it was in such working order as to enable him to produce his first series of satisfactory negatives. This telescope, we are told, Dr. Roberts intended to use for charting the heavens on a scale twice that which Argelander adopted in the Durchmusterung; but when the International Congress was called together by Admiral Mouchez in 1887 he decided to devote it to another, though kindred, field of work, which also lay well within its capabilities; viz. the photography of star clusters and nebulæ. It is for the exploration of this field that the Council has awarded to Dr. Roberts the highest honour it can confer; and when we consider what such an exploration means, one will not doubt that this honour has been worthily and properly bestowed. The work was first carried on near Liverpool, but your Medallist became dissatisfied with the conditions which surrounded his observatory, and concluded that for a more rapid and satisfactory progress he must move to some place which gave better atmospheric conditions. Careful investigation showed him that the highest ground in the neighbourhood of Crowborough gave him what he required; and on Crowborough Hill he erected his observatory and remounted his telescopes, and from that time he has made his photographs there. Like Dr. Huggins he has a reflector and a refractor on the same mounting, the former being used

for photographic work, and the latter for visual observations : both are driven by one clock in Right Ascension, but they can be moved independently in Declination.

Speaking as a Fellow of the Society, and not as the mouthpiece of the Council, I cannot but congratulate Dr. Roberts on arriving at the conclusion that a reflector is better for his purpose than a refractor. The value of the identity of focus for all the spectrum components, and the possibility of having a ratio of aperture to focal length so large as 1 to 5, give the reflector an advantage which it is difficult to overrate. Star discs, when the reflector is properly figured, must be nearer theoretical perfection, and therefore are *not* exaggerated in size for large magnitudes. Dr. Roberts tells us, however, that the adjustment of a reflector is much more difficult than that of a refractor, and this may be well believed ; but the extra trouble involved is well expended when one looks at the splendid results achieved, which are now placing him so prominently before the Society.

One of our Fellows and my immediate predecessor in this chair has perhaps unwittingly given the best proof of the excellence of the results by his measurements of the star discs taken with Dr. Roberts's reflector, and of those taken with refractors. He has shown that the images are much smaller with the former than with the latter, though the apertures employed in both cases are not such as to account for the difference from causes of diffraction.

In the report of the progress of the work carried on at the Crowborough Observatory, which has just been submitted you, occurs the following sentence which is worthy of special notice:—

"Some considerable portion of the autumn months was occupied in testing the new triple objective of 6-inch aperture, made by Messrs. T. Cooke & Sons. The lens proved to be *perfectly* 'achromatic,' no trace of secondary colour being visible around even the brightest objects. The visual and photographic foci were found, from a great number of careful experiments, to be exactly coincident, as in a reflector."

It may be that in an instrument such as this, the reflector will have a serious competitor in one respect for object-glasses of moderate sizes, but it may be doubted if it will ever be rivalled in the work which requires the utmost light-gathering power.

Turning to the absolute work that the Medallist has carried out, it should be stated that he commenced photographing the stars with various photographic lenses in 1883. The paper in which he recounted what he had done is found in the *Monthly Notices* of 1886 January. Each year since then he has contributed to the *Monthly Notices* papers on the subject of the research which he undertook, interspersed with others bearing upon stellar photography. In 1886 December he produced a photograph of the nebula in *Orion* with his 20-inch reflector, with an exposure of 15 minutes ; and almost exactly two years

after he produced a photograph of the same object with an exposure of 81 minutes, and introduced us to nebulosities in the surrounding parts which were unsuspected before. Other photographs of the same object, with more prolonged exposure, can be also remembered. A little afterwards he produced his recently published photograph of the great nebula in *Andromeda*, giving an exposure of 4 hours to the plate. In this prolonged exposure we have an example of a triumph of patience, and of instrumental perfection, though these qualities are exhibited in other instances as well. This beautiful object is depicted with its rings of nebulosity in great perfection, and we can correct the eye observations which had previously been made on it. The stars in the field are beautifully sharp and round, showing that the eye as well as the instrument had to be employed throughout that long exposure to correct changes in position of the star due to atmospheric refraction, and variations in the rate of clock-driving.

About this photograph Dr. Roberts says : "This photograph will remain a permanent record, unquestionable in accuracy, of the state or the appearance of the three nebulæ (there are two others on the plate), shown on the night when the photograph was taken, so that any changes in the form or density of the nebulosity, or in the positions or magnitudes of the stars, will in future be capable of demonstration." In 1891, it may be remarked, he did actually discuss the photographic evidence of variability in the nucleus of his great nebula.

He adds : "These photographs throw a strong light on the probable truth of the Nebular Hypothesis, for they show what appears to be the progressive evolution of a gigantic stellar system."

How many stellar photographs he has taken it would be rash to endeavour to state, but some idea of their minimum number may be formed when it is stated that in the last three reports of the work done at the different observatories inserted in the annual Report of the Council, we find that at Crowborough, about 160 plates are recorded as having been successfully exposed. Nor can I venture to estimate the researches he has carried on as to the value of different brands of plates for his purpose. The astronomical photographer has to experiment largely on commercial wares before he begins his serious work. These experiments are not publicly recorded, and hence the labour involved can only be appreciated by those engaged in similar work. In Dr. Roberts's case the experiments were neither few nor far between. It is only by patient work of this kind that advances in our knowledge of the heavens can be obtained.

Last year our Medal was awarded to a gentleman who had wonderfully increased our knowledge of double stars by his laborious and unobtrusive work ; and this year we are recognising the same kind of labour expended in bringing before us an acquaintance with those beginnings of systems which it was the privilege of but a few to scan imperfectly. Thanks to the skill which has made the 20-inch mirror, it is an obedient servant

instead of a tremulous slave, and its proper and systematized use has enabled the student of the universe at his leisure, and in the warmth of his study, to gaze at and scrutinize these ever-beautiful and mysterious objects, instead of seeking some one of them for some few hours on the finest of nights and in the cold midnight air. The solution of problems of the highest import in cosmical science is thus rendered far easier, and the thanks of all who interest themselves in such researches are due to those who, with such indomitable persistency, devote much of their time to pushing scientific discovery into those far-off regions of space.

I have not alluded to any other work which Dr. Roberts has carried out, though I might have mentioned his method of making direct engravings on plates from his negatives, a process which is certainly valuable and extremely ingenious. So far photography seems only to be limited by the physical features of the plate itself. Under the microscope the sensitive salt is a mass of small grains on which the image is received, and, as in the case of the cones in the retina, it is doubtful if a separation of two bright points is possible when they both fall on the same grain. The developed image is also a mass of small grains of probably very nearly pure metallic silver, and it may be doubted whether this also does not limit the application of photography in separating star discs very close to one another; but up to this limit, where grain becomes an important factor, it certainly has been used to the utmost by your Medallist. What the possibilities of the future may be, it would be somewhat rash to speculate. That something much more sensitive and much more homogeneous than the existing forms of silver salts as formed on a plate may be discovered seems a remote possibility. But, as I have pointed out elsewhere, the possibilities of a colour sensation being evolved must have seemed remote to our very early ancestors, who merely felt the sensations of light and form; and we must not take it as proved that nothing superior to a photograph, such as we know it now, may in the future be evolved. Be this as it may, Dr. Roberts's photographs, if they are preserved as they should be, will live to tell their own tale of what exists at the present time to students in centuries to come. That they will in our own days be rendered accessible as far as possible is proved by the issue, in June last, of that remarkable volume containing permanent prints of stars, star clusters, and nebulæ enlarged to a scale to show 24 seconds of arc to one millimetre, and in some cases but 6 seconds of arc. I cannot do better than quote the concluding paragraphs in its preface, which I had not read till I had penned my Address to this point.

"The photographs portray portions of the starry heavens in a form at all times available for study, and identically as they appear to an observer aided by a powerful telescope and clear sky for observing.

"Absent are the atmospheric tremors, the cold observatory,

the interrupting clouds, the straining of the eyes, the numbing of the limbs, the errors in recording observations, and the many hardships incurred by our predecessors, of glorious memory, in their attempts to see and fathom the ILLIMITABLE BEYOND.

"I commend the observations and the photographs herein to astronomers and students of the New Astronomy."

This last sentence your President re-echoes, and it gives him the greatest pleasure to hand to the Secretary for Dr. Roberts the Gold Medal of the Royal Astronomical Society, with the heartfelt wish that many more of our meetings may be enlivened by the beautiful pictures of the Heavens which he exhibits for our benefit, and which will be of inestimable value to those engaged in that branch of science which the Royal Astronomical Society was formed to foster.

The meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :

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